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Bell Telephone MAGAZINE

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Ideas, Men, and Things • JAMES O. PERRINE

American Telephone & Telegraph Company · New York

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Exchange Cable: The Drama of Post-war Production, *Charles G. Sinclair, Jr.*, 77

The License Contract, *Keith S. McHugh*, 88

The Thirty Millionth Bell Telephone Is Installed in Iowa, 93

The Wires Which Carry the News of the World, *Robert E. Moore*, 94

Southern New England and the Telephone, 104

The Benefit and Pension Plan Is Thirty-Five, *Charles J. Schaefer, Jr.*, 105

Bell System Advertising Wins Award, 113

Charts at Work, *Kenneth W. Haemer*, 114

Twenty-Five Years Ago in the Bell Telephone Quarterly, 124

Ideas, Men, and Things, *James O. Perrine*, 126

The Greatest Communication Network in History, 135

A Medium of Suggestion & a Record of Progress

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Leroy A. Wilson, *President;* Carroll O. Bickelhaupt, *Sec.;* Donald R. Belcher, *Treas.*

Who's Who & What's What

in This Issue

CABLES OF ALL KINDS, old and new, are familiar items of telephone plant to CHARLES G. SINCLAIR, JR., for his 35 years in the Bell System have been spent entirely in outside plant work. He joined the New York Telephone Company in 1913, and after a period of field work in the Plant Department he was assigned to outside plant engineering. In 1921 he transferred to the outside plant section of the Department of Operation and Engineering of the American Telephone and Telegraph Company. Since February 1 of this year he has been the company's outside plant engineer.

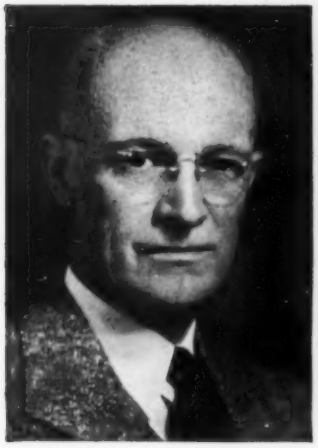
AT PRESENT Vice President of the A. T. & T. Company in charge of the Information Department, KEITH S. MCHUGH was an administrative vice president of the company from 1938 to 1946, an assistant vice president for four years before that, and commercial engineer from 1929 to 1934. In the ten years after joining the A. T. & T. Company in 1919 he had been successively an engineer with that company, general commercial engineer of the Chesapeake and Potomac Telephone Company at Washington, D. C., general commercial manager of the Upstate Area of the New York Telephone Company, and vice president of the company. That is the background which enables him to discuss the value of the historic "license contract" arrangement to a telephone system which has to serve a continent. Mr. McHugh's "Business and People" was published in last Spring's issue of this MAGAZINE.

ROBERT E. MOORE began his Bell System service in St. Louis in 1926, when he was employed by the Southwestern Bell Telephone Company as a commercial representative. In 1927 he was transferred to the Long Lines Department of the American Telephone and Telegraph Company in St. Louis, where he served as telephoto-

Charles G. Sinclair, Jr.

Keith S. McHugh

Robert E. Moore



Charles J. Schaefer, Jr.

Kenneth W. Haemer

James O. Perrine

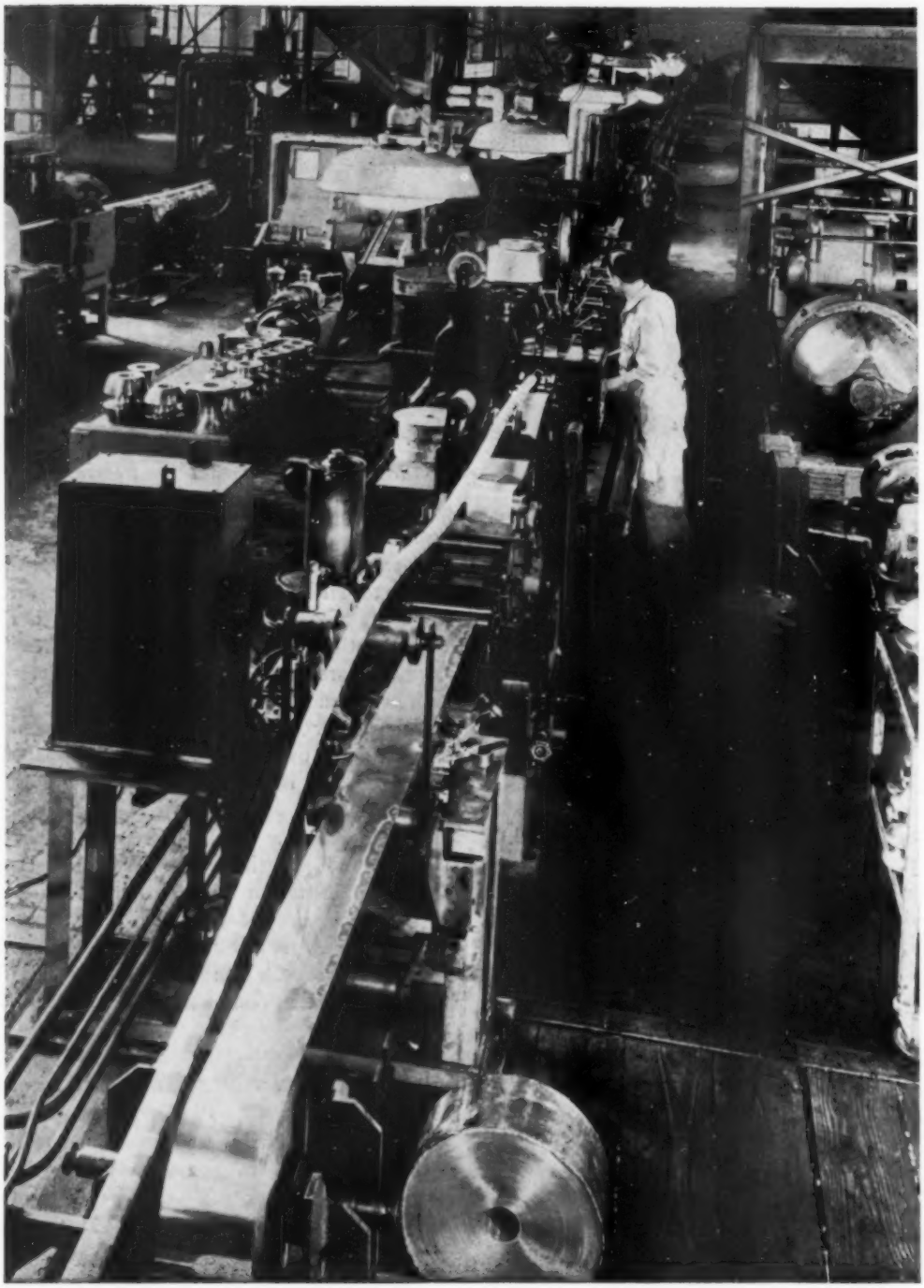
graph representative and commercial representative. In 1930 he was appointed division commercial manager for Long Lines at Cleveland, remaining in this position until 1940, when he was moved to his present assignment in New York as Press Service Manager for the Long Lines Commercial Department.

JOINING the Bell Telephone Company of Pennsylvania in 1914, CHARLES J. SCHAEFER, JR., gained experience in both traffic and commercial work before he was appointed a special assistant in the Personnel and Public Relations Department there. In 1925 he transferred to the Personnel Relations Department of the A. T. & T. Company, where he is Secretary of the Employees' Benefit Committee. His present article is his second discussion of the Benefit Plan: ten years ago, in the BELL TELEPHONE QUARTERLY for January, 1938, was published his contribution on the occasion of the 25th Anniversary of the Plan.

LEAVING the advertising field in 1926, KENNETH W. HAEMER joined the Chief Statistician's Division of the A. T. & T. Company, where he first worked on statistical presentation and production. In 1935 he turned his interest to methods, and worked on the development of a general statistical methods file which was provided to all Bell System companies. In 1942 he entered military service in the office of the Commanding General, Army Service Forces, where he headed the section engaged in developing and installing standards for the ASF Reporting System. He returned to the A. T. & T. Company in 1946, and is now in the general statistical analysis section of the Chief Statistician's Division. Mr. Haemer is Chairman of the American Statistical Association's Committee on Presentation, an editor of *The American Statistician,* and is the Telephone Representative on the ASME Committee on Graphic Presentation, authorized by the American Standards Association.

A STUDENT AND TEACHER of the physical sciences, JAMES O. PERRINE had been Professor of Electrical Engineering at Yale University when, in 1921, he joined the former Department of Development and Research of the A. T. & T. Company, where he engaged in research on the properties of materials used in dial telephone systems. Since 1925 he has been a member of the company's Information Depart-

(*Continued on page 112*)



At the distant end of this machine, installed in the Western Electric Company's Kearny Works, the new "alpeth" telephone cable emerges, to be wound on reels and shipped for urgent service. ***See the article beginning on the opposite page***

Producing more than Sixty Billion Conductor Feet of Cable In 1948, Much of It a New Type, Ranks as a Great Industrial Achievement of the Present Era

Exchange Cable: The Drama of Post-war Production

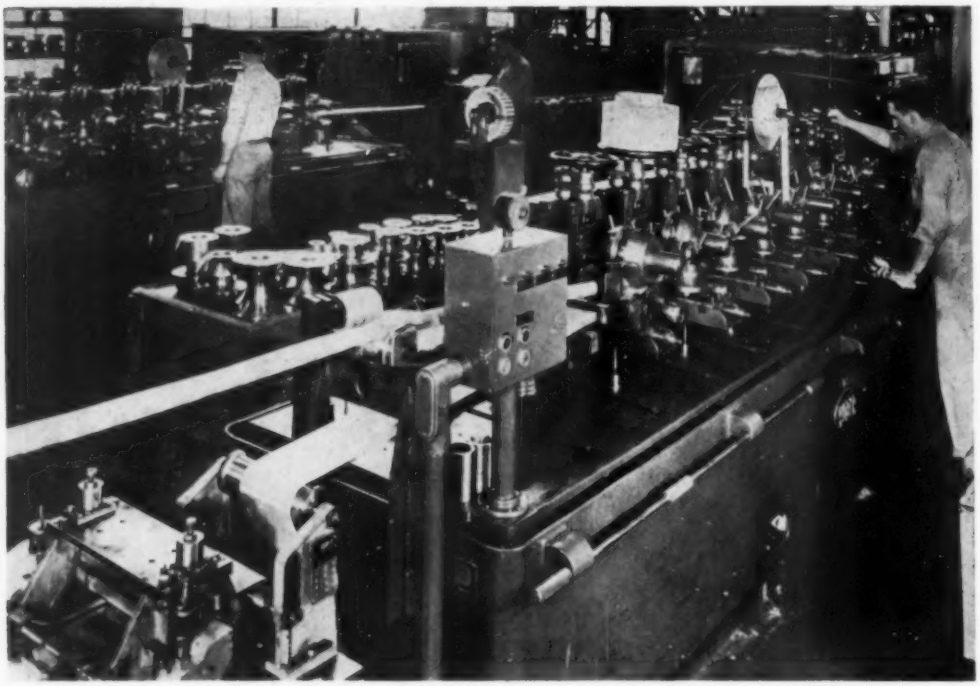
Charles G. Sinclair, Jr.

IN A CONFERENCE ROOM at the headquarters of the Bell System in New York, a group of men gathered on May 1, 1946, to discuss a problem in exchange cable production and to make a decision that would bring about its solution. Although the meeting was not attended by any publicity, the decision made that day by those men, representing the Bell Telephone Laboratories, the Western Electric Company, and the Operation and Engineering Department of the American Telephone and Telegraph Company, may well constitute a milestone in the history of the telephone industry.

During the war, when materials and manpower were not available for many normal civilian needs, demand for telephone service had increased enormously. The telephone plant facilities which had been provided before the war for growth of the business had been largely exhausted, and it had been possible to augment them only very slightly. As a result, the Bell System was confronted after the war with the necessity of manufacturing and installing, at a rate never before contemplated, all the units that go to make up the plant facilities required to give telephone service.

Central-office equipment and buildings, telephone instruments, cable, wire, poles, conduit—just to mention a few of the major items involved—all had to be obtained in unprecedented quantities and built into plant, if the demands of the public for telephone service were to be satisfied. Many of these items required large expansion of the Western Electric Company's manufacturing capacity before they could be fabricated in the necessary volume. Arrangements had to be made for a continuing flow of materials into the manufacturing processes, in huge quantities.

To meet the situation posed by the pent-up demand and expanding requirements of the public for telephone



Copper wires meet aluminum tape: the thin metal strip is applied longitudinally around the paper-wrapped core of telephone wires in the manufacture of alpeth cable

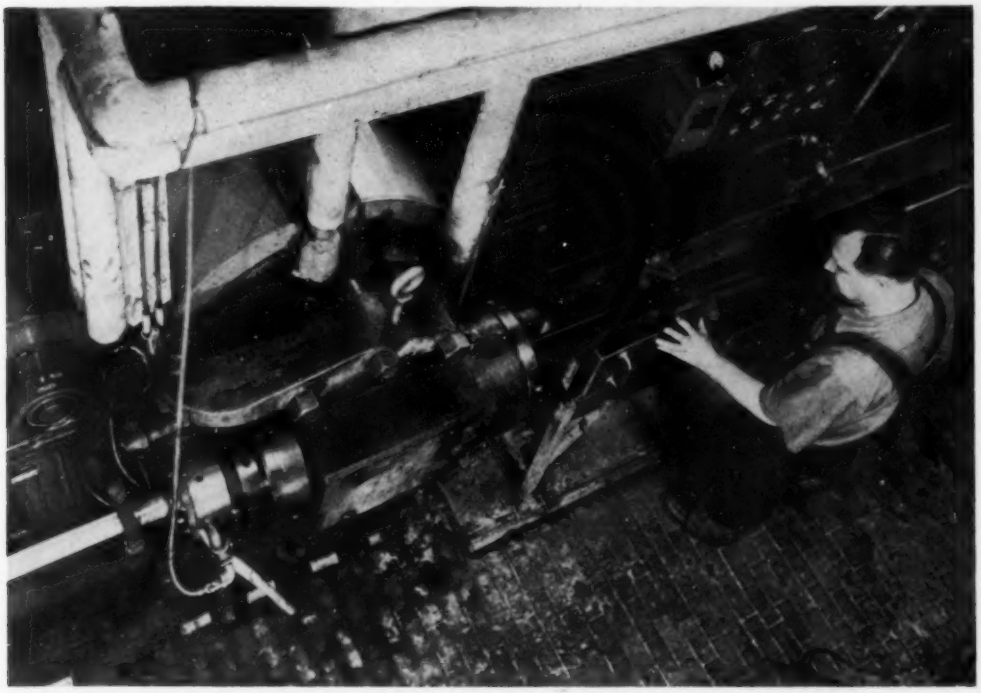
service called not only for wise planning and attention to a thousand details in order to create a well coördinated program, but it called also for great courage on the part of management.

A myriad of obstacles had to be overcome. Materials of many kinds had to be obtained. Many new employees had to be added and trained as craftsmen: linemen, cable placing gangs, cable splicers, station installers. In addition, there was the gigantic financial task of raising the required capital. Future economic trends were uncertain. To resolve, in the face of this situation, to proceed as rapidly as possible to provide telephone plant facilities that would enable the Bell System to install telephones at a rate more than twice that ever previously attained, truly required courage of a high order.

AMONG all the kinds of telephone plant for which provision had to be made, the supply of adequate quantities of exchange cable * posed a problem that was unique. Study of the situation led to the conclusion that it would be necessary to produce exchange cable at an annual rate of sixty billion (60,000,000,000) conductor feet.

Now, sixty billion conductor feet of exchange cable is a quantity that is

* Exchange cable is cable which is installed to provide the local telephone circuits in cities and towns and their environs where the number of circuits required is too large to be provided by open wires carried on pole lines.



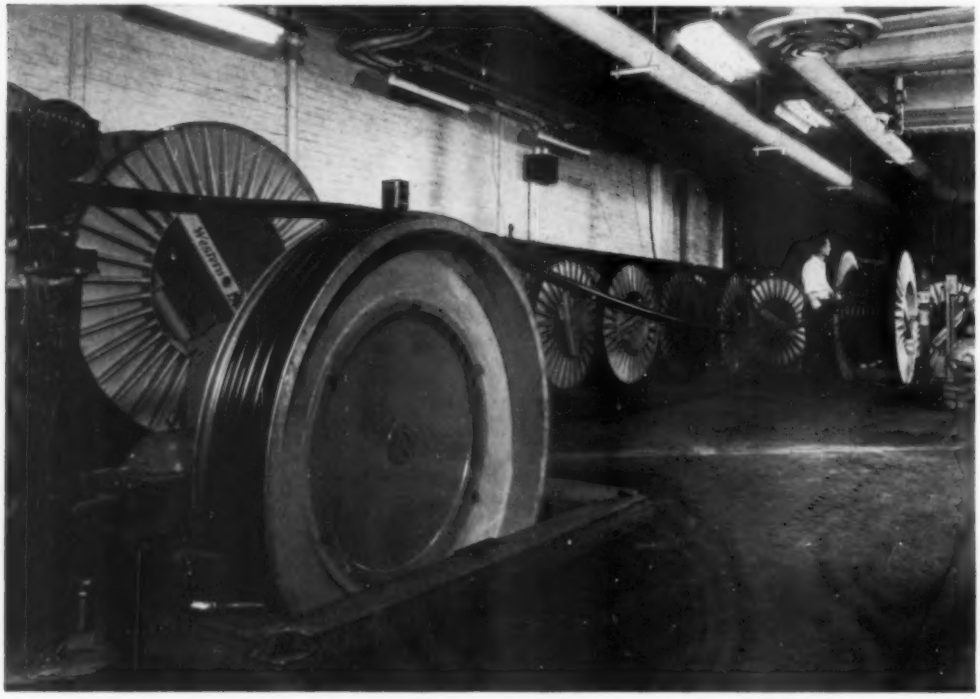
Thermoplastic added: the hot polyethylene is extruded onto the aluminum-covered core and the cable then passes into a water tank for cooling

difficult to comprehend. It is, just for instance, more exchange cable than the total that then existed in the plant of the Pacific Telephone and Telegraph Company from the Canadian to the Mexican border; it is—since the figure is, after all, of astronomical proportions—just about enough to provide twenty-four pairs of wires spanning from the earth to the moon. It is almost twice the amount of exchange cable produced for the Bell System in 1929, the year in which the pre-war peak had been attained.

The Equipment Problem

TO REACH an annual rate of production of sixty billion conductor feet required very large additions to the factory space and machinery of the Western Electric Company. A great deal of flexibility is required in such an expansion of manufacturing facilities, since the sizes of cable required from week to week are subject to wide variation.

Cables range in size from the large ones containing many hundreds of wires, for installation under busy city streets, to those carrying a relatively few wires to be erected on pole lines through the countryside to provide telephone service to the nation's farms. Consequently, whereas the sheathing machinery may be the limiting factor when the average size of cable is small, the insulating and twisting machinery, or possibly the stranding machines, tend to limit production when the average size is large.



Off and away: several turns around the spool in the foreground maintain proper tension on the completed alpeth cable for winding on the shipping reel at the right

These and other factors were foreseen of course, and equipment was added with the expectation that, regardless of variations in the average size of cable that might be required, working some of the machinery 24 hours per day and frequently 7 days per week would make possible the production of sixty billion conductor feet of cable per year.

IN ORDER to produce equipment for the armed forces, Western Electric Company's Hawthorne cable shop had been completely dismantled, and the capacity of the Kearny cable shop had been greatly reduced. The task of reconversion for the production of exchange cable involved, therefore, the removal of machinery which had been installed to manufacture war equipment and the return from storage and re-installation of machines for cable production.

In order to provide for the necessary increased manufacturing capacity, 75 percent more space had to be obtained. Efficient operation required that this additional space be adjacent to existing cable manufacturing facilities. So Western established another factory, into which manufacturing facilities for other products were moved from both the Hawthorne and Kearny plants, thus making the space available for manufacture of cable.

To make so much more cable required heavy machinery which was extremely scarce and hard to get.

Wire-drawing machinery to make the cable conductors had to be increased by more than 70 percent; machinery to apply wood-pulp insulation to the conductors had to be increased by 75 percent; machines to twist the insulated wires into cable pairs required more than a 60 percent increase. Other machinery, such as stranders, cablers, and dryers, had to be increased in varying proportions up to 100 percent.

Contacts with suppliers soon shattered hopes of early completion of the expansion program. In many cases, even such promises as delivery of some of the needed equipment in 40 to 70 weeks could not be met. The entire electrical equipment manufacturing industry, which provides the motors and electrical control units needed, was overloaded and had a huge backlog of orders. Widespread strikes in industries furnishing raw materials greatly interfered with obtaining such items as steel for chain drives, pig iron for castings, and even coal to furnish the power needed for processing the basic materials.

Careful investigation indicated, however, that the necessary materials for manufacturing cable—such as copper for wires and wood pulp for insulation—although then largely under government controls, could probably be obtained in the requisite quantities—with the exception of the lead for cable sheath.

Aluminum for Lead

LEAD, and later lead alloys, had been the traditional material of which telephone cable sheath has been made throughout practically the entire history of the industry. Its low melting point, its ductility, among other qualities, adapted lead particularly well to this use.

Unfortunately, however, while the last quarter century has seen a marked increase in demand for lead for the manufacture of storage batteries and many other purposes, nowhere in the world have any substantial additional deposits of lead ore been found. After checking all the responsible sources of information, the conclusion was inescapable that it would be extremely difficult, if not impossible, to obtain lead in sufficient quantity to provide sheath for the volume of cable production contemplated. It was this situation that brought that group of men together in the conference room at the Headquarters Building on May 1, 1946.

THE Bell Telephone Laboratories and the Western Electric Company had been studying alternative types of cable sheath for more than two decades. In the five years preceding the war, experimental lengths of cable having sheaths of material other than lead had been made available for laboratory tests. The most promising of these was a composite sheath built up in this order: around the core of insulated wires was placed a sheet of corrugated steel with a cemented longitudinal seam; this was covered by a thermoplastic material; and finally came an outer corrugated brass sheath having an overlapped longitudinal seam which was sealed by soldering. Laboratory trials of this sheath had yielded promising indications, and it was decided that sheath of this general type offered the greatest possibility of providing an adequate outer covering for that part of

the cable production for which lead would be unavailable.

In planning to go forward with this program, advantage was taken of the fact that other materials had become available during the war period which offered some improvement over the pre-war experimental cables. Aluminum had become plentiful, and it was decided to substitute this material for the corrugated steel placed directly over the core of the cable, in order to take advantage of the greater electrical conductivity of aluminum. This is of value in providing shielding for the cable against inductive disturbances and also added protection against lightning damage. Also, the possibilities of obtaining adequate amounts of sheet steel were exceedingly dim, inasmuch as the demands for this material in industry generally far exceeded the visible supply. In the pre-war samples, a rubber thermoplastic material had been placed between the two metal shells; but now a new material, polyethylene, was available. This material is a tough plastic having high dielectric strength and about 30 times as much resistance to water penetration as rubber.

It was this sheath that the group meeting on May 1, 1946, decided should be developed as an alternative to the standard lead sheath and brought into production as rapidly as possible.

Pressure for Production

NORMALLY there would be a cautious approach to any major change in design and materials for such an important and long-lived item as cable.

There would be laboratory tests of a few sample lengths. If these were promising, field laboratory trials would then be inaugurated. If these also proved successful, a few commercial installations would follow. The behavior of the new material would be observed closely over a period of perhaps several years before concluding that extensive use of it appeared advisable.

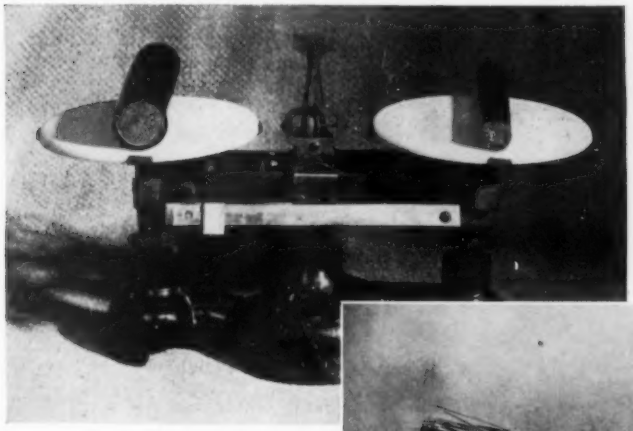
These steps might very likely have required a five-year period before reaching a decision such as that made in 1946. In 1946 there wasn't that much time.

In making the decision to proceed with a venture of this sort, the probability was recognized that changes in design or material might prove to be necessary as further study of the sheath and the facilities needed for its manufacture progressed. These are the inevitable concomitants of treading untried paths.

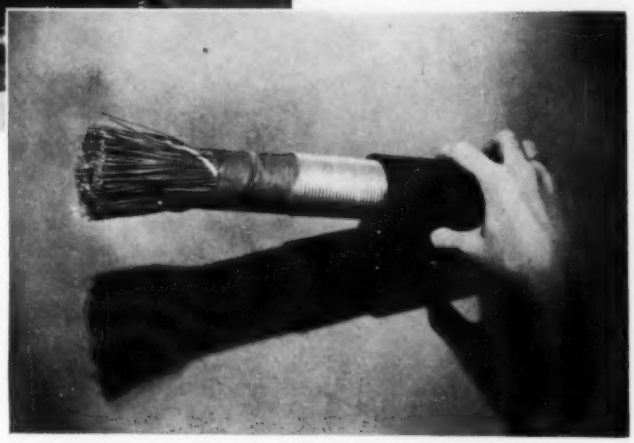
BEFORE many months had passed, laboratory study had indeed determined that changes in design would be necessary in order to make the outer brass covering suitable. The changes found necessary introduced difficult manufacturing problems. Meanwhile, time was running on apace and provision of facilities for producing the increased amount of cable, except for sheath, were moving ahead rapidly. Another decision had to be made if we were not to lose production for want of sheath.

The decision was made.

It was to make the cable without the outer brass shell, relying upon the relatively high impermeability of the polyethylene material and the barrier of the aluminum tape around the core to exclude moisture from the



Same weight: the alpeth cable at the left contains 152 pairs of 22-gauge copper wire, as against 51 pairs of the same gauge in the lead-sheathed cable at the right



Alpeth cable: from left to right, pulp-insulated copper telephone wires, paper wrapping, corrugated aluminum covering, and outer sheath of polyethylene compound

cable. This, of course, contemplated that the polyethylene would be exposed to the elements. To forestall the disintegration which might otherwise result from the exposure of such an organic material to sunlight and atmosphere, the polyethylene, normally milky white in color, was compounded with carbon black and an anti-oxidant, as is commonly done with rubber compounds which are to be similarly exposed.

This sheath came to be known as "Alpeth," a name coined from the key letters of *al*uminum and poly*eth*ylene.

If the decision taken in May of 1946 to proceed without delay to manufacture and use brass sheath cable was daring, the decision to go forward with the alpeth sheath was little short of derring-do. Alpeth had not been subjected to even the limited pre-war tests applied to the brass sheath. Reliance was placed solely upon laboratory study of the polyethylene material. True, this laboratory study was exhaustive, comprising exposure to temperature and humidity cycles as well as to ultraviolet rays. These are what are known as "accelerated aging" tests and, while an extremely useful tool in appraising the characteristics of a material intended for outdoor use, they are rarely relied upon as a complete substitute for field trials under the conditions of commercial installations. But time did not permit trials of the usual kind to be made.

Experimental lengths of the new cable were made available early in 1947 for trial purposes. A wholly new splicing technique had to be de-

Training thousands of cable splicers in the technique of making a water-tight enclosure comparable to the lead-sleeve wiped joint was a major undertaking

vised to provide a water-tight enclosure such as is afforded by the lead sleeve and wiped joints used to enclose splices in lead-sheathed cable. Devising and refining methods of splicing represented a major development in itself. Here again, some of the newer materials, such as neoprene, were used to ensure a closure which would remain water-tight and durable despite exposure to sun and air. The quick training in the operating companies of thousands of cable splicers in the new techniques was no small achievement.

Advantages of Alpeth

As is usual in such an undertaking, unforeseen contingencies arose and unexpected obstacles were encountered; but each was successfully surmounted, and in September of 1947 the first lengths of cable having the new type of sheath came off the production line.

Since those first lengths were fabricated, last September, production of the new type of sheath has increased steadily until now about 30 percent of all the exchange cable being manufactured is made with the alpeth sheath. As is to be expected in the manufacture of an entirely new product, the alpeth sheath has not been entirely without faults. These have, however, been of relatively rare occurrence and there is every reason to suppose that further study and experience will point the way to their practical elimination. A substantial amount of field experience has been gained in the installation of the new cable, so that we are now in a position to appraise its relative value.

The new cable has a number of characteristics which recommend it. The sheath is extremely light, with the result that even the largest size cables weigh only about half as much as lead-covered cables. Smaller sized cables are relatively even lighter. This of course brings savings in freight charges and facilitates handling the cable during installation. It also permits aerial installation on smaller and lighter suspension strand than would be required for lead covered cable.

Advantage is taken of the light weight of the cable and the fact that the polyethylene has an extremely low coefficient of friction by installing the cable in conduit in longer lengths than would be practicable with lead covered cable; thus the amount of splicing is reduced. In many cases, where splices are not required in a manhole for distribution purposes, successive underground sections are pulled in one length, merely bending the cable to rack it in the intermediate manhole, without splicing it. Where splices are necessary, the amount of work involved is somewhat more than in the case of lead-covered cable, but it is expected that in time further developments should substantially eliminate this disadvantage. For underground use, the alpeth sheath has one extremely important advantage. It is not susceptible to corrosion, which is a frequent cause of failure of lead sheath. Finally, the cost of the alpeth sheath is appreciably less than that of lead sheath.

All in all, it appears that although born as the child of necessity, the new type of sheath may well have a permanent place in cable manufacture, even if, in years to come, the supply of lead should become sufficient to provide sheath for the amount of cable required to be manufactured.

Runaway Demand

CURRENTLY, the Western Electric Company is producing exchange cable at a rate somewhat above 60 billion conductor-feet annually: the goal that

New materials, as well as a new technique, are required for making splices in alpeth cable

Reels of exchange cable ready for shipment from the Kearny Works of the Western Electric Company

was set at that meeting on May 1, 1946. It is indeed fortunate that this is so; because, as the public demand for telephones has grown to proportions far in excess of expectations, the requirements for cable have grown apace, so that today exchange cable is the most critical element of plant in providing facilities for new telephones.

It may be of interest to reflect upon why this is so.

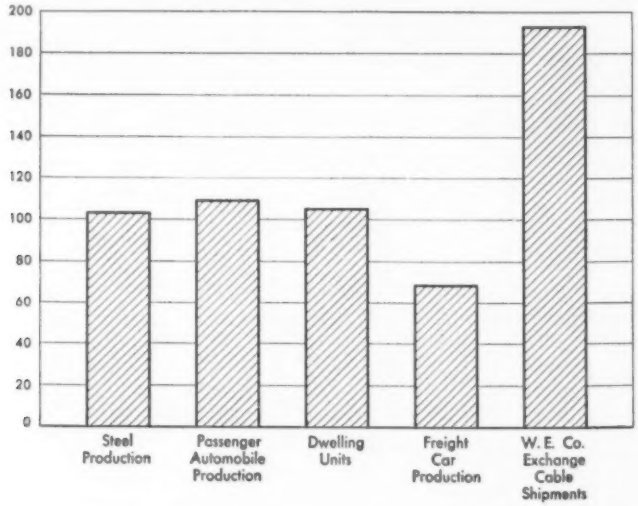
To most readers, the question will undoubtedly have occurred as to why the program for the production of cable, central-office equipment, and telephone instruments was not in balance. The answer is that it was!

Sixty billion conductor feet of exchange cable per year wasn't selected because of any cryptic significance of that number. On the contrary, it was expected that this would be sufficient, within a year or two, to care for all the held orders and to provide cable plant adequate to meet the continuing demand for telephones —as then foreseen. But alas! The unprecedented demand for service could not reasonably have been foreseen. Even bold forecasts, predicting a considerably greater demand than had ever been experienced before, were still short of the service customers wanted. Plans for the manufacture of central-office equipment and telephone instruments contemplated that, in addition to caring for growth, the quantities planned would also provide for an active program of dial conversions. As the unprecedented demand continued, it

was, of course, possible to deflect the central-office equipment and instrument production originally intended for dial conversions to help meet the unexpectedly large demand for additional telephones and defer dial conversions to the extent necessary. On the other hand, in the case of exchange cable production, there was no such cushion to absorb the shock of the sharply increased demand. Exchange cable thus became the bottleneck in the effort to clear held orders.

Production at an annual rate above 60 billion conductor-feet is far from an easy task. It calls for carrying on certain of the manufacturing operations 24 hours a day, frequently 7 days a week. To obtain the materials necessary—the copper, the wood pulp for insulation, the lead, the aluminum, the polyethylene, as well as other ingredients—presents a Herculean task of supply, which is being met only with the utmost difficulty. Within recent months there have been times when the Western Electric Company has had to scrape the bottoms of the bins hard to keep the machinery in operation, so closely has the production program been geared to ultimate availability of materials.

The achievement in so greatly increasing the volume of cable manufacture, while putting into production an entirely new type of sheath and finding the means of successfully installing it, rates as one of the great industrial accomplishments of the post-war era.



Estimated Bell System exchange cable shipments for 1948 compared with the expected 1948 production of certain other items. The highest pre-war year is taken as 100 percent for each item

Central Work on Common Problems, to Avoid Duplication and Prevent Waste, Is Assured by the Relationship between A.T.&T. and the Operating Bell System Companies

The License Contract

Keith S. McHugh

THE LICENSE CONTRACT is a contract between the American Telephone and Telegraph Company and each of the operating telephone companies of the Bell System. Under it, all work together to provide a coördinated nationwide communication service. Each operating company does locally the work that can best be done locally, and the A. T. & T. Company is responsible for work that can best be done by a central organization.

If one single big company were providing telephone service everywhere, it would be natural, and in fact essential, for it to have a central staff of people carrying on research, handling patents and financing, assisting the local operating areas and divisions, and making studies and developing methods to the benefit of the service in all places where the company operated.

The same functions are equally necessary when, as in the Bell System, several companies, rather than one big single company, have the responsibility together.

Having several companies, each responsible for providing service in its own territory, has been of great importance in making it possible for the Bell System to give the best telephone service in the world, for it has aided in decentralizing responsibility and authority so that local people who know local conditions have the freedom and ability to act as circumstances require.

But the centralization of certain work has likewise been of the utmost value. And since we have several companies, instead of one big company, assurance that this central work will be performed is provided by a contract between the A. T. & T. Company, which does the work, and each of the Bell System operating companies.

The name "license contract" goes back to the early days of the business, when local companies were first licensed to use Bell telephones; but for years the contract has guaranteed that the operating companies will get the benefit of important services ren-

dered by the parent company, including research, financing, and engineering. To reimburse the A. T. & T. Company, the operating companies pay a percentage—since 1929 it has been 1½ percent—of their operating revenues (excluding certain minor items). This is payment for value received and for services rendered.

EACH OF US knows from his own knowledge that both local and centralized work are needed to give good telephone service.

It takes telephone people in Memphis to provide service in Memphis, others in Spokane to give service in Spokane, and so on in every community.

And in each operating company headquarters there are people who work on problems that affect the service in all the areas where the company operates. Their work is part of the cost of providing service, just as the wages of every operator and craftsman are part of the total cost.

The same is true of the central group at Bell System headquarters, who are working on problems that are common to all the companies. And just as some of the revenues of each operating company must be used to pay the cost of work done in its own headquarters, so likewise some of the revenues of all the companies are used to pay the cost of work done at System headquarters.

There are two main reasons for centralizing certain functions:

First, it is economical and efficient —it is just plain horse-sense—to do central work on common problems and make the results available to all concerned. Duplication of effort is avoided, waste prevented, progress quickened.

Second, coördination is needed. This is particularly important in our business, because the very essence of telephone service is to interconnect people wherever they may be, and the over-all quality of the service in one place depends on, and contributes to, the quality of service in other places.

What the Operating Companies Get under the Contract

THE CENTRALIZED SERVICES rendered by A. T. & T. under the license contract fall into five groups. Let us look briefly at each:

1. RESEARCH AND DEVELOPMENT

The contract provides that A. T. & T. will maintain facilities for constant research. The Bell Laboratories (owned by A. T. & T. jointly with the Western Electric Company, the System's manufacturing and supply unit) render this service. Each step forward in telephone progress has depended on research. Alexander Graham Bell's invention was only the first of thousands of inventions needed to create the telephone system. Starting from scratch, the Bell Laboratories, which grew out of Bell's original attic workshop, have developed switchboards, cables, better telephone instruments, modern dial apparatus, and a whole vast array of devices and systems. Without these there could be no telephone service as we know it today.

This great research organization—the largest industrial laboratory in the world—employs a staff of outstanding scientists. For each

operating company to try to duplicate it would be not merely wasteful—it would be utterly impossible, for there wouldn't be enough competent scientists to go 'round.

The cost of research is a major item of expense among the license contract services. The return in value to the operating companies and to telephone users, however, is tremendous, for research has enormously increased the scope and quality of Bell telephone service and has lowered plant and operating costs—below what they would otherwise have to be—by hundreds of millions of dollars. (Just to give one example: Sixty years years ago the cost of wire in telephone cable, per pair-mile installed, was more that ten times the cost per pair-mile in today's 2121-pair cable.)

A. T. & T. pays the cost of Bell Laboratories' basic research and development work, including the acquiring of new fundamental knowledge. Western Electric pays for development and design work specifically related to Western's products, and this expense becomes part of the total cost of equipment that Western makes and sells. For example, A. T. & T. would pay for developing a new metal alloy which might have various uses, and Western would pay for the design of a particular product in which the alloy was used.

2. Operating Advice and Assistance.

The license contract provides that the A. T. & T. Company shall maintain a staff to give the operating companies assistance in all phases of telephony. The General Departments of the A. T. & T. Company comprise this staff. They furnish advise and assistance to the companies in general engineering, plant, traffic, commercial, accounting, patent, legal, administrative, personnel, treasury and all other matters contributing to the efficient and economical conduct of the business.

This staff analyzes experience and results in all territories, and in consultation with the operating companies develops new methods which afford the basis for coördinated improvement of service. Such centralized work is essential to bring about the orderly, economical introduction of improved equipment and more efficient practices. It makes it possible readily to bring the total System experience to bear on any particular operating problem in a particular area. Similarly, it enables all the companies to realize gains on a broad front by using or adapting methods that have been found advantageous through localized trial and experiment. If there were no centralized staff, each company would have to duplicate its work, at much higher cost.

3. Patent Rights

The A. T. & T. Company owns or has rights to use patents covering most of the apparatus and equipment used to provide telephone service.

The operating companies not only obtain the right to use these inventions and those coming along in the future; the contract also obliges the A. T. & T. Company to

defend the companies and to save them from loss from any patent infringement suits brought against them for using recommended apparatus. These rights and this protection are of very great value to the operating companies.

4. Financial Advice and Assistance

The A. T. & T. Company provides financial advice and assistance to the operating companies, including help in securing capital funds for service improvement and expansion. An important part of this is that A. T. & T. obtains money from investors and keeps a pool of funds available. The operating companies can borrow from this pool on short notice. This enables them to keep their own cash balance low, get money for construction as needed, and repay it later. The cost of financing is kept down—the money is on hand when wanted.

5. Availability of Materials

The A. T. & T. Company agrees to maintain arrangements for the manufacture of telephone apparatus and materials under its patent rights; the operating companies are assured of a dependable source of top quality products at reasonable prices.

A. T. & T. Makes No Profit from The License Contract Payments

The payments made to A. T. & T. by the operating companies are for necessary services and valuable rights. The companies cannot efficiently or economically perform these services for themselves, nor can they obtain the rights and services elsewhere. The A. T. & T. Company makes no profit out of the arrangement; in all but one of the last ten years the cost to A. T. & T. in rendering the services, excluding any return on capital, has been more than the payments made by the operating companies.

Could each company pay its share of the actual total cost of the services, instead of paying a percentage of revenue? In principle, either basis could produce satisfactory results, although experience over the years shows that the former method would have cost the operating companies more. Also, use of a percentage of revenues has the practical advantage of being simpler.

When an operating company increases its rates to customers, payment of a percentage of revenues means of course that the amount paid to A. T. & T. for the license contract services is also somewhat increased. However, expenses of the A. T. & T. Company in rendering the services are also going up, for the same reasons that oblige the operating companies to increase their rates. Increasing the license contract payments proportionately with increased revenues helps to make the payments come closer to meeting the actual cost of rendering the services.

The License Contract Services Increase Bell System Efficiency

A nation-wide telephone system is possible only through coördination; the license contract has provided the coördinating link; the improved serv-

ice and lowered cost that have resulted through the years have been of great benefit to telephone users.

Unlike a purely investing company, which exists simply to invest money, and all of whose costs are incurred for the benefit of its stockholders alone, the A. T. & T. Company incurs its expenses to improve and make more efficient the operations of the telephone companies in which it owns stock. Like the wages of telephone operators, these expenses are necessary and advantageous to users; they are a worth-while expenditure in the conduct of the business.

The very ownership of the operating companies by A. T. & T. is the end result of financing their needs for capital to build telephone facilities. In the early days, as we have seen, local people who were starting telephone exchanges obtained licenses to use Bell telephones. Many of these local companies found it hard to raise capital to build plant, so the American Company raised money and advanced it to them, taking stock in return. Even then, a central source of capital was needed to develop local as well as long distance telephone service.

Out of these beginnings, and out of the need for centralized research and for standardization of methods and apparatus, the Bell System of today developed. The financing activity of A. T. & T., the conduct of research, the performance of the centralized part of the over-all Bell System telephone job, and the maintenance of a corporate organization for these purposes, are all essential services which cannot be eliminated without seriously impairing the efficiency of the nation's telephone service. They have been, in fact, of fundamental importance in giving this country far more telephone service, of better quality and value, than exists in the rest of the world. Long experience has demonstrated the need for *both* centralization and decentralization—for doing local work on local problems, central work on common problems. And the license contract, which grew out of the original licensing of Bell instruments, has contributed essentially to the unmatched progress of the telephone in America.

The Thirty Millionth Bell Telephone Is Installed in Iowa

THE THIRTY MILLIONTH Bell System telephone was installed, last June 29, in Marshalltown, Ia. It was installed, by the Northwestern Bell Telephone Company, in the home of Harold Bragg. Mr. Bragg is a veteran of World War II and an engineer for a furnace company in Marshalltown.

The implications of the event are significant.

It took the Bell System more than 45 years to attain its first ten million telephones; it took not quite 20 years for the second ten million; it took less than six years for the third ten million—of which 8,200,000 have been added since V–J Day. In the last ten years, the number of Bell System telephones in service has nearly doubled: from 15,460,000 to the present 30,000,000.

Mr. Bragg placed the first call over the newly-installed instrument to a brother, W. G. Bragg, in Seattle, Washington. Mayor Donald E. Taylor of Marshalltown followed, and called his mother in Brainerd, Minnesota.

Next came a three-way exchange of greetings by long distance. Vice President Clifford L. Sampson of the Northwestern Bell Telephone Company placed the "conference" call from the Bragg residence to President Leroy A. Wilson of the American Telephone and Telegraph Company, in New York, and to President Russell J. Hopley of the Northwestern Company, in Omaha. Messrs. Wilson and Hopley welcomed Bragg as a telephone subscriber.

TODAY'S Bell System plant investment is about $8,000,000,000. This is almost double what it was 10 years ago. Nearly two-thirds of this 10-year gain has been made since the war. Similarly, there are today about 675,000 Bell System employees, or more than twice the total of a decade ago. Stockholders of the American Telephone and Telegraph Company, parent company of the System, now total nearly 750,000.

The number of telephone conversations completed daily in the Bell System now exceeds 125,000,000, as compared to around 70,000,000 per day ten years ago.

Today 115,000,000 miles of wire interconnect Bell System telephones. Ten years ago there were 83,000,000 miles.

Harold Bragg makes the first call as Installer Thomas Sorensen stands by. On the telephone is a metal plate identifying it as "The thirty-millionth Bell System telephone, installed in the home of Mr. and Mrs. Harold Bragg, Marshalltown, Iowa, June 29, 1948"

The Bell System's Private-Line Services Enable the Press Associations to Supply News Quickly and Fully to Papers and Broadcasting Stations

The Wires Which Carry the News of the World

Robert E. Moore

BEHIND THE NEWS which you read in your daily newspaper and hear by radio there are complex news-gathering and news-writing and news-editing organizations, in part local and in part nation-wide and even international. And behind all but the local part of the job are Bell System services which are at work day and night to keep a continuous stream of news flowing throughout the United States and into Canada and Mexico. These services—chiefly "private line" facilities of the Long Lines Department—require the use of about 600,000 miles of our circuits, more than 8,700 teletypewriters, many hundreds of switchboards, and vast quantities of other equipment.

Our customers who use all these facilities in their specialized task of gathering and distributing news are the press associations, so called: The Associated Press, the International News Service, the United Press Associations, and similar organizations.

Their customers are, in turn, the approximately 1,750 daily newspapers of general circulation and the approximately 1,900 commercial radio stations in the United States. There are still others to the north and to the south of our borders.

To the people of this country its newspapers and radio stations bring up-to-the-minute news of every sort: not only local news but significant and interesting accounts from every corner of this land and from many a capital and focal point around the world. Along with the news come on-the-spot photographs of people and events of importance or of special interest.

The American people are among the best informed in the world. They are also among the most critical of the timeliness of the news they get and of the form in which it is presented to them.

The operations of the press associations may be divided into three

The main news room in New York of one of the press associations

broad categories: gathering the news and assembling it at central points; editing the news and preparing it for use; and delivering the news to customers—newspapers and radio stations.

It is this last function—transportation—with which the Bell System is so importantly concerned. In order to understand the System's part, it is going to be necessary to get a picture of the whole operation. And although there are variations among them, the operations of the several associations conform in general to the same pattern. That pattern is of specialization and departmentalization—of organizations so complicated and yet so closely coördinated as to remind one of assembly-line production.

In just about every city in the nation—with exceptions to be noted in the next breath—are correspondents of the associations. They are experienced reporters; they know what is newsy, timely, of interest; they write their stories either on their own initiative or on assignment—and send them in to the regional bureaus,

In certain strategic cities—and these are the exceptions just referred to—there are regional offices or bureaus having staff reporters who also originate stories. And it is to these bureaus that the correspondents send their stories—stories from abroad as well as from domestic correspondents.

That is a quick look at the first operation: gathering and assembling the news.

The editing and rewriting of the news and the preparation of special features are handled at the several bureaus and the main offices of the associations. These editorial operations are expertly done; the associations have specialists in foreign affairs, national politics, sports, finance, and other topics, who know what the cus-

tomers—newspapers and radio stations—want, and can supply it.

So now the product—*news*—is all assembled and packed and ready for shipment.

For shipment, in almost all cases, over Bell System private-line circuits which may be thought of as sort of an endless belt arrangement for conveying news: with the bureaus adding items as the belt moves past them and the customers taking off the news as it reaches them—although without diminishing the supply.

Let's take a look, then, at the process.

THE TELETYPEWRITER private-line networks of the press associations usually consist of from two to six nation-wide main trunk line services which interconnect the headquarters and main bureau offices with other offices at intermediate cities. These trunk lines are used from 18 to 24 hours daily to disseminate all general news reports. The news stories are prepared on teletypewriter machines in the form of perforated tape for transmission over the private-line networks. This tape is fed into and operates automatic teletypewriter sending equipment, which transmits the news over the private-line services to newspapers and radio stations, where it is received simultaneously at all points in typewritten page form.

The headquarters office and the bureau offices in the larger cities on the trunk lines are equipped to transmit and receive, although the bulk of the transmission on these services originates in the bureaus in New York, Washington, Chicago, and San Francisco. About 800,000 words of news, for example, passes through the New York bureau of one of the press associations each day.

In the center is the editorial department of a press association office, where the news is prepared for transmission

Regional wires, operating eight to 16 hours daily, branch out from cities where bureau offices are maintained; and here switching arrangements are provided in order to separate and permit the transmission of news of particular interest to these areas in more condensed form. News originating at an outlying point on a re-

gional circuit is sent to a bureau office, and if it is other than local in character and of sufficient importance, it is re-transmitted on the trunk system.

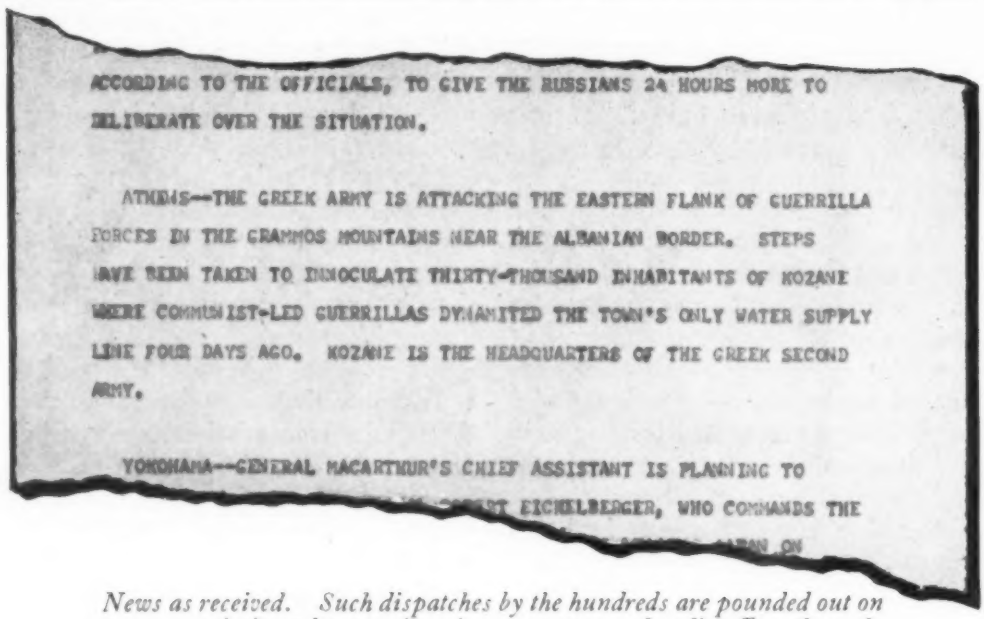
As the size or circulation of a newspaper governs the quantity of the news it requires, it is apparent that a newspaper in a small city would be unable to handle the entire wordage from a main trunk news wire but would be covered amply by the condensed report as carried by a regional wire. These regional reports contain the principal items of national and international news together with full coverage of news of particular interest to the citizens of that locality.

In some cases the main trunk wires are "duplexed." Normally a teletypewriter wire system operates by means of one two-way channel, while in duplex service it is possible to transmit in two directions simultaneously, thus giving in effect two separate services.

A further development of duplex service is the "round robin," which is so called because of arrangements which provide two one-way channels, one clockwise and the other counter clockwise, on a route which covers a number of cities and terminates at the starting point. This enables an operator at any station on the circuit which is equipped for sending to transmit copy to all the points around the "round-robin" and receive an identical copy of the material he sent on a receiving machine located beside his sending machine.

One particular advantage of "round-robin" duplex service is that the operator is immediately aware of any circuit trouble; for it follows that his received copy, having gone around the entire circuit, will reveal interruptions on the circuit as well as any errors that may have occurred during the transmission to the other points. Further, in the case of service failure to a point on one channel, the arrangement of the "round-robin" is such that important news flashes can be sent out on the other channel

These teletypewriters of one of the press associations transmit news at the rate of 60 words a minute



ACCORDING TO THE OFFICIALS, TO GIVE THE RUSSIANS 24 HOURS MORE TO DELIBERATE OVER THE SITUATION.

ATHENS--THE GREEK ARMY IS ATTACKING THE EASTERN FLANK OF GUERRILLA FORCES IN THE GRAMMOS MOUNTAINS NEAR THE ALBANIAN BORDER. STEPS HAVE BEEN TAKEN TO INNOCULATE THIRTY-THOUSAND INHABITANTS OF KOZANE WHERE COMMUNIST-LED GUERRILLAS DYNAMITED THE TOWN'S ONLY WATER SUPPLY LINE FOUR DAYS AGO. KOZANE IS THE HEADQUARTERS OF THE GREEK SECOND ARMY.

YOKOHAMA--GENERAL MACARTHUR'S CHIEF ASSISTANT IS PLANNING TO [illegible] EICHELBERGER, WHO COMMANDS THE [illegible]

News as received. Such dispatches by the hundreds are pounded out on press association teletypewriters in newspaper and radio offices throughout the country

and partial service be given the point in trouble.

Supplemental service is another offering of considerable value to the press.

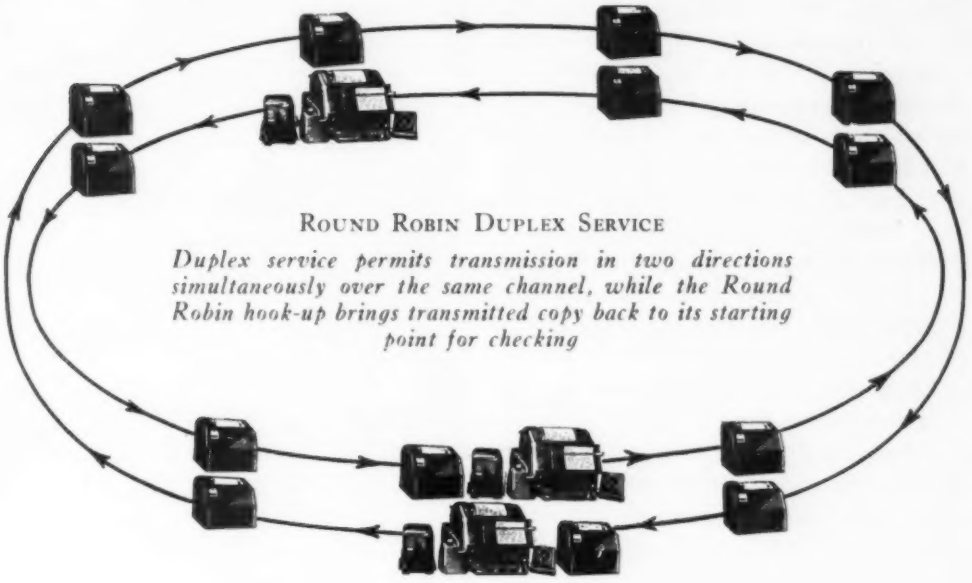
The general news reports have become so complicated and the coverage so great that many items of news have to be curtailed in order to supply a complete report. The result is that many newspapers and radio stations have demanded more detailed news concerning sports, movies, business, politics, social activities and other items; and in order to meet this demand, special wires are now used for the purpose of supplying this coverage.

By means of this supplemental teletypewriter service, which may be provided for a period of one or more hours to any or all of the points already receiving service from a primary wire, additional or overflow traffic may be delivered without loss of time. For example, in the handling of financial news over press services, as the volume of sales of shares mounts the summaries become greater and, as the closing hours are reached, the reports become so heavy that additional services are needed to deliver the complete report as quickly as is possible after its compilation.

Serving Radio

RADIO STATIONS receive their news reports from the press associations over both the general news wires and special radio news wires.

From the general news wires, commentators who present their broadcasts in individual style edit the full coverage report to suit their particular requirements. These commentators have large followings and are very popular, and their presentations are carried by the broadcasting com-



ROUND ROBIN DUPLEX SERVICE

Duplex service permits transmission in two directions simultaneously over the same channel, while the Round Robin hook-up brings transmitted copy back to its starting point for checking

panies over their network stations.

Over the special radio news wires a "processed" report is sent on a regularly scheduled basis, in some cases every fifteen minutes, and the "copy" is so prepared that the latest report includes last minute news as well as a resumé of previous news. This type of report is very popular, particularly with small stations, since there is no necessity for further editing before an announcer gives it over the air.

The war period was responsible for a great development in radio news broadcasting. Before the war, not all radio stations broadcast news, and those which did offered only a partial coverage. With the great volume of war news coming over the press wires continuously, an increasing demand developed for more frequent radio broadcasts of news. As a result, the schedules were stepped up, and many stations broadcast news reports as often as once an hour—with more complete reports every few hours. This activity caused a considerable development of the already existing use of private lines for special radio news, and was responsible for establishment of new teletypewriter networks.

To illustrate the rapid growth of these services:—one network started with one station receiving its report, and has developed in about seven years until it now involves about 68,000 miles of circuit and more than 1,000 radio stations. This network is nation-wide, and is provided with switches at sectional locations so that it may be split into several networks or returned to a single operating network as occasion demands. On these networks the special radio news is sent from press association headquarters or from bureau office locations to the radio stations.

A similar development has occurred because of the increased public

interest in sports: the press associations have established special circuits, operating 10 to 12 hours daily, for the sole purpose of disseminating sports news in far greater detail than would be possible on the general news circuits. Although these sports services have been established in their present form only since late in 1944, they now operate to a large number of cities and extend into every section of the country.

On occasions of special news events, it is necessary for the press associations to supplement their regular news service with temporary services, either by adding stations close to the news source or by establishing a separate service from the news source to a main bureau office.

Some of the more important events covered in this manner are the national political conventions and the national election, primary elections each year in various states, and the baseball world series.

This telephotograph transmitter is compact and readily portable

Other events of a more extended nature, such as major and minor league baseball pennant races, college football and basketball games, usually require the rearrangement of existing facilities and the addition of extra hours of service.

A telephotograph operator prepares to transmit a photograph by wire

Morse Still Used

THE CHANGE from Morse (i.e., code telegraph) to teletypewriter service was natural, as the speed and dependability of the teletypewriter and the elimination of translation from telegraph signals to typed copy exactly fitted the needs of press associations and newspapers. However, Morse service still has its place in the press field, especially at locations where power is not available to operate teletypewriter motors and proper protection against the weather is not provided for the teletypewriter machines. Such locations are common to baseball parks, football fields, and

scenes of flood or disaster. Availability and portability are also factors in favor of Morse equipment.

Prior to 1925 Morse service was predominant in the press private line field. Practically all this use has been superseded by teletypewriter service, although until about five years ago it continued to be the most practical service arrangement to obtain news at temporary locations such as the press boxes at football and baseball stadia, conventions, and prize fights, where the operation of teletypewriter service was not feasible. However, the press associations have now arranged for the use of modified sending and receiving teletypewriter equipment at improved and protected locations so that the play-by-play developments of these news events may be sent directly into their trunk systems.

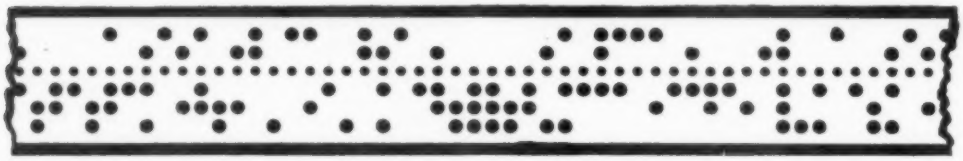
The use of private line telephone service by the press associations during their early days was confined principally to the use of short-period telephone service. This service was used extensively during the transitional period from Morse to teletypewriter private line service. It is still used to a limited degree to deliver a brief news report to small papers which specialize in local news and cannot use or afford a general or regional news report. The service is usually from a bureau office which operates on the main trunk or regional teletypewriter system and from which reports are telephoned to from one to three receiving newspapers. The service is usually furnished for three relatively short periods each day, and enables the newspaper to receive, edit, and set in type as much of the news as possible in advance and then receive the latest developments just prior to its press time. This type of service is being replaced gradually by teletypewriter exchange service (TWX) and private line teletypewriter service.

Pictures by Wire

"PICTURES BY WIRE," better known to telephone people as telephotograph service, is the most exacting and spectacular Bell System service used in the press field. It is being greatly expanded, because of the recognition of the news value of spot news pictures and the present-day trend to publish a news picture with a brief caption which conveys to the readers a complete news story and requires no further editorial or printed comment.

News pictures which are transmitted by wire are handled for newspapers throughout the country by three large picture agencies which

Safe! This photograph was transmitted by wire before being reproduced here. There is no apparent loss of clarity and detail



Perforated tape such as this actuates the press service teletypewriters

are affiliated with the major press associations. Each of these agencies operates its own telephotograph network system, using Bell System services. Their systems utilize channels specially adapted for transmission of picture material and also full-period telephone service—which are channels normally provided for ordinary telephone service. All of these are leased on a contract basis for 24 hours daily.

Short-period telephone contract services are also used daily on a part-time basis, utilizing channels provided for ordinary telephone service. By means of such services, pictures are sent to newspapers whose addition to the network services is not justified from the expense angle.

In addition to contract services, these agencies are large users of toll message telephone service for picture transmission. This is used to cover special news events which occur in cities not on their networks. Such picture stories are covered by sending photographers with portable transmitting equipment to the place where the picture story occurs; after the pictures are obtained, they are transmitted over toll message telephone circuits to the nearest network station and from there sent throughout the country.

The telephotograph network of one of the press associations is now beginning its 12th year of operation. Since it was almost nation-wide from the outset, the basic layout has not changed to any great extent except for the addition of other cities to the basic network and the use of the service by other newspapers in cities already connected to the network.

With the increasing demand for spot news pictures, the trend is toward the establishment of regional or state telephotograph networks. This, if continued, will result in a coverage for pictures closely paralleling the news coverage networks; i.e., with the main trunk line for pictures of national interest and the regional or state circuits for pictures of local interest.

Setting Type by Wire

AN INTERESTING USE of another Bell System service, private-line teletypewriter service for teletype*setter* operation, permits one of the large weekly news magazines to edit every issue in New York and yet print it simultaneously in Philadelphia, Chicago, and Los Angeles.

Teletypesetter equipment was developed to provide for the automatic operation of typesetting machines. The equipment consists of a perforator and a teletypesetter operating unit, the latter being attached directly to the typesetting machine. The perforator (keyboard) punches code combinations corresponding to keyboard characters into a tape, which, when fed into the operating unit in a distant printing plant, will automati-

cally operate a linecasting machine, producing the lines of typecast in type metal from which pages are printed.*

News material is received in the centralized editorial office from branch offices, various press associations, wire services, staff writers, newspapers and foreign correspondents. After being edited, the material is prepared in tape form for transmission over a private-line network to the printing plant. There, by means of a reperforator, it is received in the form of perforated tape. This tape is then fed into the teletypesetter operating unit.

Prior to transmission to the printing plants, the editorial office procures a teletype copy from the tape for use in preparing a "dummy" or working duplicate of the magazine. Changes are made until the entire copy is estimated to fit the space provided for it. This is done to insure perfect transmitted copy, since the final tape transmission operates the typesetting equipment simultaneously in all three distant printing plants.

This operation makes possible the publication of the complete magazine in identical form in three strategically located cities for simultaneous, economical, nation-wide distribution.

PRESS ASSOCIATIONS and large metropolitan newspapers use Bell System overseas telephone service for coverage of spot news events occurring in cities throughout the world where overseas telephone service is now available.

In addition to random use of this service, our overseas short-period telephone contract service is employed when it is necessary to transmit large volumes of foreign news directly to New York after it has been assembled at a central point. It is then telephoned to New York daily during the contract periods, where it is recorded, transcribed, edited, and published.

OF THE COUNTRY'S English-language daily newspapers, about 95 percent receive their news from one or more of the press associations by means of Bell System private line teletypewriter service. At least 90 percent of the country's commercial radio stations receive news—from 16 to 24 hours per day—by the same means.

When it comes to telephotography, newspapers representing 75 percent of the daily circulation in the country receive pictures which have been transmitted over Bell System facilities; and newspapers representing about 60 percent of the total daily circulation receive pictures from telephotograph equipment located on their own premises or in the same city.

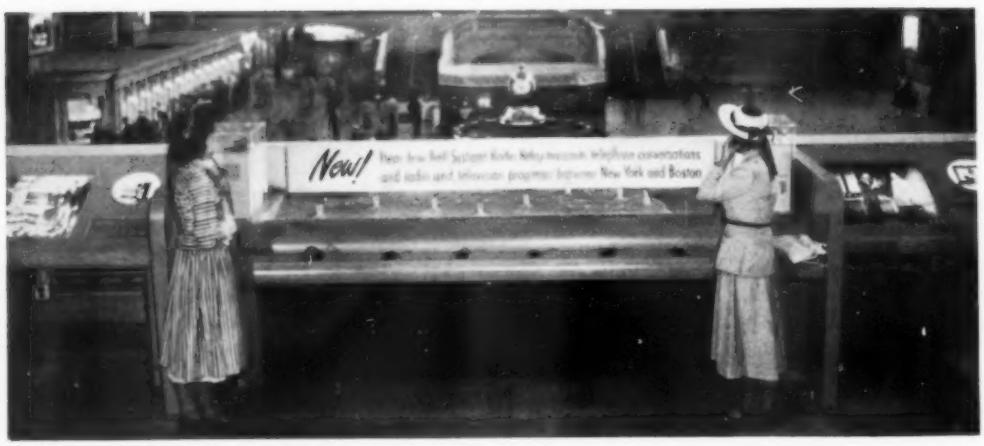
Such facts make clear the importance of the Bell System's part in the story which lies behind the news. Its importance is, in fact, unique among the industries to which the System furnishes private-line services. For it is by means of these services that the press associations both assemble the product which they sell and then ship it out to their customers.

* Special teletypewriter equipment was developed which uses a six-unit code rather than the five-unit code normally employed for teletypewriter service, because of the large number of type characters involved in teletypesetter operation, including small letters (lower case) as well as capital letters (upper case) and figures (upper case) and other operations and special combinations of letters peculiar to typecasting. It also provides for typing in either red or black for the identification of headings, foreign characters, and special editorial instructions.

ON THE EAST BALCONY of Grand Central Terminal in New York City is installed a full-scale replica of a colonial New England village called "Main Street, Southern New England." Here the New York, New Haven and Hartford Railroad has reproduced a white pillared church and other buildings such as once stood about a village green, together with displays of products of modern New England.

The telephone was invented in Boston. The first commercial telephone exchange was in New Haven. It was from southern New England that the telephone spread across the nation and throughout the world. Now there stands on the balcony, opposite the white church, a telephone display which is a coöperative undertaking of four Bell System companies serving southern New England: New England Telephone and Telegraph Co., Southern New England Telephone Co., New York Telephone Co., and the Long Lines Department of A. T. & T. Co.

Southern New England and The Telephone



The display is a model of the radio relay system which transmits messages between New York and Boston. Music is actually broadcast between the miniature towers visible at either side of the sign, and can be interrupted by passing a hand between them across the radio beam. The sign invites one to pick up a receiver and "Hear how Bell System's Radio Relay transmits telephone conversations and radio and television programs between New York and Boston." At the left is an illustration of the first New Haven switchboard, and at the right is one of Bell in Boston

The Methods of Employee Protection Adopted by the Bell System Companies in 1913 Have Demonstrated Their Value To Hundreds of Thousands of Telephone Workers

The Benefit and Pension Plan Is Thirty-five

Charles J. Schaefer, Jr.

THIRTY-FIVE YEARS AGO last January, the Bell System became one of a small group of industries which were pioneering in the establishment of benefit and pension plans for their employees. The plan then established by the System was sound and reasonable. It was entirely "non-contributory": that is, the entire cost was borne by the company. It was a balanced plan, designed to provide help of several kinds to meet various needs.

Today, 35 years later, the Bell System plan is still among the leaders. When all the features of the sickness disability benefits, the accident disability benefits, the death benefits, the disability pensions, and the service pensions are tallied, they add up to a plan which ranks among the very best.*

There is no yardstick which can measure the human values involved, but a few figures will reveal some significant facts.

During the first year of the plan's operation, the Bell System companies, including Western Electric, paid out $1,153,128 for all the purposes covered by the plan.

In the 35th year of the plan's operation, 1947, the amount was $148,820,000. That sum was about 8⅓ percent of the System's payroll.

During the 35 years ending December 31, 1947, the total paid out under the plan has been $1,006,755,995. This sum is made up of the following items:

Sickness disability benefits	$207,915,097
Accident disability benefits	26,116,448
Death benefits	46,140,118
Disability pensions	9,259,832
Service pensions disbursed 1913–1927, and payments to Pension Trust Funds * 1928–1947	717,324,500

* This general discussion can be neither complete not definitive. For a comprehensive and exact statement of the terms and provisions of the plan the reader is referred to the pamphlet "Plan for Employees' Pensions, Disability Benefits and Death Benefits." The booklet "Facts about the Benefit Plan" gives a simple explanation.

* These were established to accrue currently the cost of future service pensions on an actuarial basis. At the end of 1947 the aggregate Pension Trust Funds of the 26 Bell System Companies, including Western Electric and Bell Laboratories, stood at $826,475,000.

Before 1913

THE BELL SYSTEM'S benefit and pension plan went into effect on January 1, 1913; but it did not spring full-blown into being overnight. A great deal of research, of planning, of plain hard work preceded its adoption.

At the time when our plan became effective there were, in addition to certain governmental plans, some pension plans in older industries—more particularly the railroads. But by and large, such plans covered only a small proportion of the employees in industry. For others, any forms of protection, if provided at all, were entirely discretionary, and there was little assurance or uniformity of treatment. With increasing industrial expansion, however, the need for such protective measures for employees was becoming more fully recognized.

Before 1913, a number of the Bell System companies had informal practices which provided certain financial assistance in connection with disability and death and which assisted in varying degree those long-service employees who, because of age or other infirmities, were unable to continue on active duty.

In other instances, some protection was provided by mutual-benefit associations or through similar employee activities—with or without company participation. A few of the older companies had somewhat uniform practices in effect which provided some means of retirement pay treatment pending the adoption of the Bell System plan, and one company had adopted a formal retirement plan as early as 1906.

Our plan, as adopted by each of the Bell System companies, provided uniformly substantial benefit and pension protection; and, through interchange agreements, it enabled employees to transfer between companies in the System while continuing to enjoy the advantages of the plan. This was and has continued to be distinctly advantageous to both the employees and the companies.

In the past 35 years, the Bell System benefit and pension plan has been amended on eleven occasions to meet changing conditions, and these amendments have meant a broadening of the provisions of the plan, to the advantage of employees.

THE EFFECT of the System's benefit and pension plan upon employees is to cushion the blows of illness, accident, old age, disability, death. Its economic and administrative justification lies, however, in its ability to maintain within an essential public service an organization of sustained spirit and vitality. Contributing substantially to these attributes are the features of the plan which provide an orderly program of retirement for older employees.

The principles underlying the plan are that it be designed to meet effectively, for the future as well as the present, the needs of the business; that it be financially secure; and that it balance fairly the particular interests of telephone workers, telephone users, telephone stockholders. These three groups comprise the telephone business. If the plan is to continue—and to continue to be sound—it must recognize that their interests are interdependent.

All of the plan's benefit and pension provisions are important in achieving these purposes.

The sickness, accident, and death benefits—which, like pensions, are provided at company expense—bear a fairly constant relationship to wage and salary payments, and so they are paid out of current expenses as required. The terms and provisions of these benefits and the provisions of the pension plan are summarized on the next two pages.

The Bell System Pension Plan

THIS PLAN is generally accepted by pension authorities who are familiar with its provisions as an exceptionally good and indeed outstanding industrial plan. It is financially sound, and its eligibility provisions treat all employees alike on the basis of their wages or salaries and the length of their Bell System service.

It is a trusteed plan, for which funds are provided on a sound actuarial basis so that pensions will be available for all employees when they retire. The pension bill of the Bell System Companies to insure this is estimated to be about $125,000,000 for the year 1948. Accruals as determined from time to time will be required yearly to pay future pensions when the pension roll will be many times its present proportions.

It is important—it is essential to the best interests of every employee—that the terms and conditions of the plan be maintained in accordance with sound pension practices. A pension plan is not something which can be changed from year to year; pension planning is by its nature a long-term proposition, and must be so recognized if it is to be more than a temporary gesture.

Pension plans cost a lot of money. In order to provide essential security for the future, there must be reasonable assurance of meeting the bill in the years ahead—in good years and bad years. Without such security, a pension plan is an unreliable promise. If it fails in this respect, resulting hardship and distress come upon those who looked forward to and relied upon its benefits, at a time in life when they may be unable to offset such disaster.

A good pension plan must be thoughtfully conceived, carefully designed, fairly administered, and soundly financed for the long pull. Pensions should be provided in reasonable amounts, but not in amounts so great as to make their continuance uncertain nor to make the over-all cost of the pension plan extravagant in the eyes of the public.

How the Bell System Pension Plan Compares

IN MAKING COMPARISONS between pensions provided by the Bell System companies and by other companies, certain important factors should be given due weight.

Our plan is non-contributory, and its payments are provided without any direct or indirect cost to employees; therefore, in making comparisons with plans to which employees contribute, it must be kept in mind that a part of the pension under such plans is purchased by the employees' own contributions. On this basis it can be shown that the Bell System pension compares most favorably with the part provided solely at company expense in these other plans.

Another point to take into account is that while every Bell employee begins, on the day he or she enters the

(*Continued on page 110*)

Summary of Benefits and Pensions

Disability Benefits

Sickness Disability, including injuries *not* arising in the course of employment by the company:

Benefits begin with 4 weeks' full pay and 9 weeks' half pay after 2 years' service and increase at intervals of service until they become 52 weeks' full pay after 25 years of service.

Accident Disability, injuries *arising in* the course of employment by the company:

Employee becomes eligible immediately upon entering the service. For total disability, the benefits are 13 weeks' full pay up to 15 years' service; beginning with 15 years' service and at 5-year intervals thereafter the full-pay benefits increase by 13 weeks until they are 52 weeks' full pay after 25 years' service. In each instance, following the full-pay period, half-pay continues for the duration of total disability.

For partial disability, the benefits are 100 percent of loss in earning capacity during the scheduled full-pay periods and 50 percent of loss in earning capacity during the half-pay periods. Payments do not extend beyond six years.

Death Benefits

The underlying purpose of death benefits is to continue the income for a definite period while dependent relatives of deceased employees adjust themselves to the changed conditions after earnings or pensions cease. Death benefits are paid to specified beneficiaries for definite periods and under conditions which are explained in the booklets already referred to.

Death Benefits, in cases of death resulting from sickness or accidents *not* arising in the course of employment:

Maximum benefits begin with 4 months' wages at 2 years' service, and increase by 1 month's wages for each additional year of service until they amount to 1 year's wages after 10 years' service.

Death Benefits, in cases of death resulting from accidents *arising in* course of employment:

Employee becomes eligible immediately upon entering the service. Maximum benefits are 3 years' pay, not exceeding $10,000; but if a greater amount could have been paid under the above sickness death benefit schedule, the maximum is increased to such amount. In addition —funeral expense not exceeding $250.

Service Pensions

Retirement on service pension is provided for employees coming under the following classifications:

Class A—Employees whose age is 60 years or more (women 55 or more) and whose term of employment has been 20 years or more.

Class B—Employees whose age is 55 to 59 (women 50 to 54) and whose term of employment has been 25 years or more.

Class C—Employees whose age is less than 55 years (women less than 50) and whose term of employment has been 30 years or more.

Employees in Class A may be retired with a service pension at their own request or at the discretion of the Benefit Committee.* Employees in Classes B and C, while not eligible to be retired at their own request, may be retired with service pensions if their cases are approved by the Committee. An employee 65 years of age is retired at the end of the month in which that age is reached.

Disability Pensions

After 15 years of service, employees becoming totally disabled by sickness or injury outside of employment become entitled to disability pensions. After expiration of disability benefits, disability pension continues as long as the employee is prevented by disability from resuming active service. Where an employee is also eligible for a service pension, that is granted instead of the disability pension.

Amount of Pensions

One percent of average annual pay for last (or highest) 10 years of service multiplied by years of service. Minimum pension is $50 per month, except that it may be less in disability pension cases based on less than 20 years of service and in cases of part-time employees.

When an employee retired on service pension becomes entitled to a Social Security Primary Insurance Benefit based solely on Bell System employment, the service pension otherwise payable under the plan, is reduced by one-half of amount of Primary Insurance Benefit attributable to Bell System employment and wages—the part which results from the company's direct tax contributions.

Pension Funds

Service pensions are paid from the pension trust funds, which are irrevocably devoted to service pension purpose only; they are not, and cannot become, a part of the assets of any of the companies.

Supplementary Assistance

Benefits outside the plan may be paid as supplementary assistance in exceptional cases where there is a need. This provides a degree of flexibility for the proper administration of individual cases when additional relief is required beyond that which can be covered under reasonable uniform schedules having general application.

* A Benefit Committee comprised of five members is appointed by the Board of Directors in each of the Bell System companies to administer its Plan. Each of the major departments of a company is usually represented on its Committee.

business, to acquire credited service for eligibility to the advantages of the pension plan, many other plans limit employee participation in terms of age, of earnings, of length of service.

A number of plans require, for instance, that employees be 25, 30, or even 40 years old before they can receive pension credits or participate in the pension plan. According to a recent analysis by the Bankers Trust Company, the most common age requirement is 30 years. If this were done in computing Bell System pensions, it would reduce most of them by very substantial amounts.

Another requirement of some pension plans is a certain period of service—usually from one to five years—before an employee may participate in the pension plan. This practice, too, if applied to Bell System pensions, would reduce them substantially. If, for example, five years of service were required before an employee began to receive pension credits, the amount of the service pension would be reduced, on the average, by about 15 percent.

Some pension plans compute pensions differently for employees in different wage or salary groups. In the Bell System, all pensions are figured on exactly the same basis for everybody.

Another common practice in pension plans is to "discount" pensions granted ahead of the normal retirement age. In these plans, the normal retirement age is usually 65; and for each year of retirement before 65, the pension as computed by the regular formula is discounted—that is, reduced—by about 1/15th. On the average, Bell System men retire at age 62 years and women at 58. If the discount feature common to most plans were applied to our pensions, men's pensions in the average case would be reduced by about 20 percent and women's pensions by almost 50 percent.

The Pension Plan and Social Security

ALTHOUGH it is customary in the great majority of industrial plans to make adjustments in pensions, directly or indirectly, because of Social Security benefits, this common practice has been subject to considerable misunderstanding. Many incorrect and misleading statements regarding such coördination of company pensions with the contributory governmental benefits have been made. In view of the questions which sometimes arise, it may be of interest to review briefly the underlying principles regarding the practice as it applies to the Bell System plan.

When this plan was established, thirty-five years ago, it was provided that, if a governmental agency should establish the payment of pensions, the full amount of such pensions would be deducted from the pensions otherwise payable under the plan. It never was intended or provided that the full service pensions computed under the regular one-percent formula should be in addition to pensions or old-age benefits which might later become payable under the law.

It is important to keep this in mind, since it is basic to a correct understanding of the method adopted for the adjustment of the company's pensions on account of the old-age benefits which first became payable under the Social Security Act on January 1, 1940.

In view of the fact that employees must contribute half the funds from which their old-age benefits are paid under the Social Security system, the Bell System pension plan provisions requiring the deduction of the entire federal old-age benefit from the company pension did not seem proper. After careful study, it was decided that the fairest way of coördinating the pension plan with the Social Security Act would be to deduct from the Bell System service pension beginning at 65 *only one-half* of the Primary Insurance Benefit based on Bell System wages and employment: the half representing what is payable on account of the Company's tax contributions for those benefits. In consequence, the retired employee now receives at company expense after attaining 65 years of age, just as much from the company through the Pension Trust Fund and through the Social Security law as he would have received directly as a company pension if there were no Social Security law. On top of that, he gets the half of the Primary Insurance Benefit which results from his own contributions under the Social Security law.

Social Security old-age benefits result from a form of group insurance as contrasted with benefits provided on the basis of individual contributions. As is true of any insurance system, the Social Security Act gives the assurance of protection to all who become eligible for payments, at the general expense of all who contribute in the form of taxes to the fund from which the payments are made. The total amount of Social Security benefits which any individual may receive bears no relation to the total of the taxes which have been contributed either by him or in his behalf. As under all insurance systems, some people stand to get more than others; some will receive more and others less than the total amount of taxes which they and their employers have contributed. This "averaging" is the fundamental principle on which all forms of insurance are based. Just as it is inconsistent with the basic theory of the Social Security Act to relate the Social Security benefits received by an employee to the taxes he has paid, it is also inconsistent to relate the deductions from his company pension to the taxes paid by the company in his individual case.

SOCIAL SECURITY is no doubt here to stay, and over the years companies are expected to provide half the funds from which such benefits are paid. It follows that they must, over the long pull, coördinate the pensions provided under their private plans with Social Security payments. Money paid to the Government by the companies to provide pensions for their employees must be considered along with money paid out to meet the expenses of their private pension plans. Both of these items represent real costs to the company; in the long run its pension plan, to avoid duplication of pensions at company expense and to be of a sound and continuing character, must give full weight to the fact that half the Social Security payments are financed by the company.

Most industrial pension plans today either directly or through pension computation formulae deduct one-half or all of the Social Security old-age benefit. In other words, industrial pension plans both old and

new recognize the need for adjustments based on the amount of Social Security benefits. The Bell System plan is similar in this respect to other company pension plans.

Security of the Bell System Pension Plan

TOO MUCH EMPHASIS cannot be placed on the prime essential of any really good pension plan: *security*.

Unless there is security, employees have no assurance of receiving the pension to which they have become eligible upon retirement. When an insecure pension plan fails, it works grave hardship on many employees at a time when their earning powers have decreased or ceased entirely and when they will probably have little chance to get going again to provide for their later years. This has been the unfortunate experience in a number of other plans over the years, especially during depression periods.

The Bell System plan is outstanding in respect to its security. The pension funds trusteed under the terms of the plan must be used solely and entirely for service pension purposes. Amounts accrued on an actuarial basis are paid into the funds currently, to provide for payment in full of the pensions as they become due and for the continuation of such payments during the remaining lifetime of the retired employee. The amounts thus provided over the years are sufficient to meet, by a substantial margin, all matured pension liability; and the balance in the funds, with current accruals and interest earnings, will provide for future pensions as employees become eligible to them.

With such essential security, with due recognition of important pension principles, and with the use of good judgment, the Bell System benefit and pension plan will continue in the years ahead to fulfill its important functions, to the mutual advantage of employees, stockholders, and the public.

Who's Who & What's What

(*Continued from page 75*)

ment, and assistant vice president since 1939. Here he coördinates the lecture-demonstration activities of the Associated Companies, assists them in the preparation of semi-technical and popular talks and demonstrations for various civic bodies and public groups, and, upon invitation, himself gives talks and demonstrations throughout the country before universities and colleges, professional and academic engineering societies, and similar organizations. Dr. Perrine contributed several articles to the former BELL TELEPHONE QUARTERLY between 1925 and 1936, and is an editor of the *Bell System Technical Journal*.

1947

ANNUAL ADVERTISING AWARDS

HONORABLE MENTION TO

AMERICAN TELEPHONE & TELEGRAPH CO.
(BELL TELEPHONE SYSTEM)

&

N. W. AYER & SON, INCORPORATED

FOR A CAMPAIGN IN NATIONAL MAGAZINES

ADMINISTRATIVE BOARD

JURY OF AWARDS

NATIONAL magazine advertisements of the Bell System during 1947 have won an "Honorable Mention" for the A. T. & T. Company and the N. W. Ayer & Son, Inc., advertising agency. In publishing the awards, the trade magazine *Advertising & Selling* said in part of the A. T. & T. series:

"The Bell Telephone System believes that all business in a democratic country begins with public permission and exists by public approval. If this belief is true, the company feels that business should be cheerfully willing to tell the public about its policies, its present state of operation, its plans for the future.

"This is not an easy task. The people who make up the public are generally busy with their own affairs and are not particularly prone to read about the telephone business—or any other business, for that matter.

"That the Bell System has succeeded in overcoming this obstacle is shown by its Informative Series of advertisement which last year appeared in some 50 national magazines. . . .

"The Bell Telephone System, however, measures the effectiveness of this campaign not so much by readership figures, but by the regard the general public has for the telephone business, its efficiency and courtesy, its standing as a good citizen in the community."

The first "Honorable Mention" Award to the A. T. & T. Company was made in 1939 for an informative advertisement appearing in national magazines. During 1943, 1944, and 1945 the regular awards were suspended and a new series started called the War Time Advertising Awards. The "100 Best War Advertisements" were selected annually. During each of these three years, two A. T. & T. advertisements won places in this selected group of advertisements.

Graphic Representation Makes Many Kinds of Facts Easier To Understand, and Contributes Much to the Successful Operation of Our Business

Charts at Work

Kenneth W. Haemer

THE TELEPHONE BUSINESS is made to order for the use of statistics—or so it has been often said. One reason why ours is a "statistical" business is that efficient operation demands it. Day by day, week by week, month by month, year by year, we must make careful and continuous measurement of a great many different telephone activities, to be sure that the progress or performance of hundreds of telephone matters is as it should be. This enormous need for facts is so important at all levels of the organization that if opportunities for their collection were not inherent in the business, we would have to find ways to provide them.

Fortunately, the nature of our business makes it relatively easy to obtain many of the statistics we need. Providing telephone service is a retail business, involving millions of individual transactions daily, most of which are recorded. These records provide the feeder material that, properly selected and summarized, becomes one kind of statistics. In addition, our business includes hundreds of measurable operations that go on behind the scenes, out of sight and sound of the telephone user. These measurements, too, are fertile sources of valuable statistical data.

But although the nature of the job has made an extensive use of statistics both necessary and possible, they would not be available for use unless the people who carry on the business recognized this need and did something about it. Without common purposes and uniform operating practices throughout the Bell System, few figures of any value could be gathered. Without an acute awareness of the importance of accurate, detailed data on all phases of operation, many valuable statistics would remain unreported and unused. This need for timely information on all aspects of the business was foreseen early in the development of telephony, and it is being met throughout the Bell System.

Pioneering Charts for Business Use

CHARTS—statistics in graphic form—have been used in our business since long before figures were dignified by the name *statistics*. We were among the pioneers in the development of charts for business use; not only for an occasional conference or special study, but as a basic tool in the day-to-day operation and management of the business. We discovered very early that this method of putting figures into picture form was very much better, for certain purposes, than the use of the same figures in tabular form—or, for that matter, in any other form.

Charts have the advantage of all picture forms: they visualize the story so that it can be seen at a glance. They are forceful, dramatic, economical of the reader's time, and less likely to be misinterpreted than other forms of presentation. Sooner or later, every important measurable fact about our business finds its way into a chart.

A roll-call of even the more important uses of statistical charts in the Bell System would be a long one indeed. Many of these uses relate to subjects so specialized that they would not be appropriate in a general article such as this. The examples shown on these pages were selected to illustrate some of the more common every-day uses to which charts are put in our business.

One of the easiest charts to understand is the pie chart. It looks simple and "non-statistical," and therefore is very useful for presenting facts to readers untrained in the use of charts. For this kind of audience

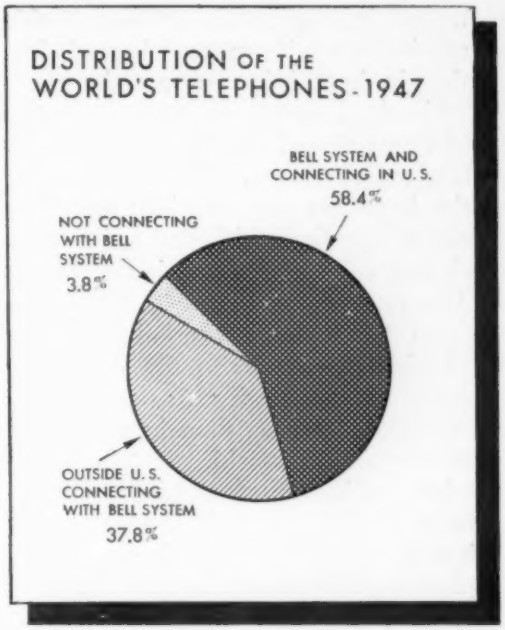

DISTRIBUTION OF THE WORLD'S TELEPHONES - 1947
BELL SYSTEM AND CONNECTING IN U. S.
58.4%
NOT CONNECTING WITH BELL SYSTEM
3.8%
OUTSIDE U. S. CONNECTING WITH BELL SYSTEM
37.8%

Figure 1

it is probably the best type of chart to use for showing the component parts of a single total. The example in Figure 1 shows how the world's telephones were distributed as of January 1, 1947. It demonstrates at a glance, in a forceful and direct manner, that more than half of the world's telephones were in the United States and that of the remainder almost all could be connected with telephones in the United States. Charts of this type are used principally as a means of explaining such facts about the Bell System to employees, to the public, and to the owners of the business. Management's responsibility to these three groups includes the responsibility of keeping each informed about many such facts, and very often a chart provides the best method of transmitting the information.

Another simple chart form is illus-

trated in Figure 2. Although this one looks a trifle more "charty" than the pie chart, it is easy to understand. This chart simply compares a series of items placed side by side to facilitate measurement. The thickness of the bars has no meaning; the bars are merely lines thickened for emphasis and only their length is significant. The example in Figure 2, borrowed from "Telephone Statistics of the World," shows clearly that there are more telephones per 100 persons in the United States than in any other country in the world. It also shows where each country stands in relation to each of the others. Although this bar type is most useful for such simple comparisons as this, it is also used for summarizing comparisons that are not so simple. For example, another bar chart, looking quite similar to Figure 2, might show, instead, a comparison of the coefficients of correlation between the volume of telephone traffic and the volume of business in a number of other industries. This points up the fact that many simple-appearing charts are not easy to understand because the concept contained in them is not a familiar one. The picture may be clear, but its meaning will not be unless the reader is acquainted with the subject and with the particular method of measurement used to portray it.

Charts 1 and 2 show a cross-section of how matters stood at a particular time. They are, in effect, "still" pictures. "Moving" pictures, showing the changes over a period of time, although not quite so simple, are of great value in tracing the trends of the business. Chart 3 is a good example of such an action picture. This picture of telephone growth, viewed in 1919 perspective, was used in the A. T. & T. Company Annual Report of that year. Although the number of telephones in service was small by today's standards, it represented an extremely rapid

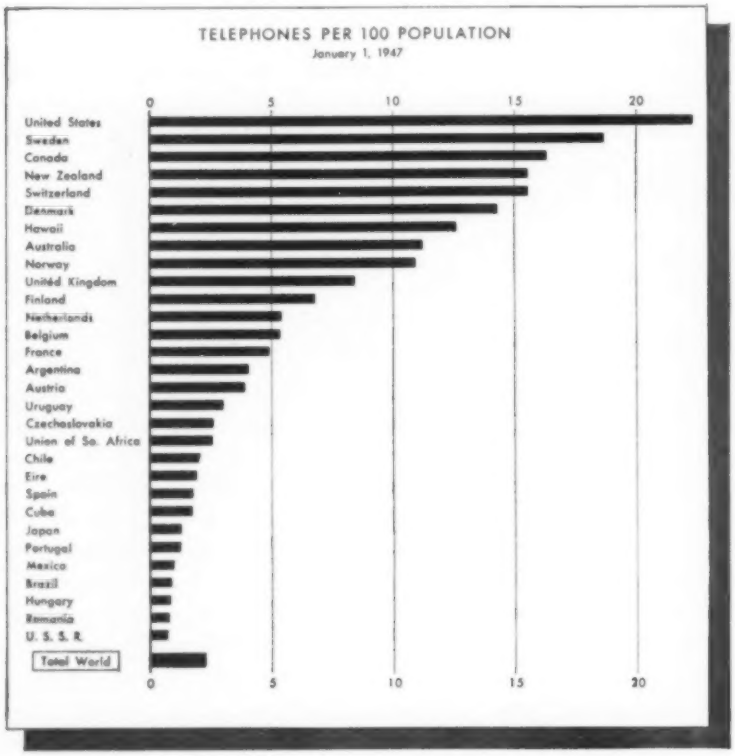


Figure 2

growth, and the chart shows this unmistakably.

The current version of this chart, shown in Figure 4, proves that in charts, too, all things are relative. Over a period of about the same number of years, Chart 3 shows an increase of about 12 million and Chart 4 about 20 million telephones; yet because it started from such a low point, the 12 million increase seems greater than the 20 million. This impression is further heightened by the difference in the shape of the two charts, and emphasizes the importance of using the same size and shape for charts that are to be compared. What a careful comparison of the two charts actually does show is that the relative increase was very much greater during the earlier period, although the absolute growth was greater during the latter period.

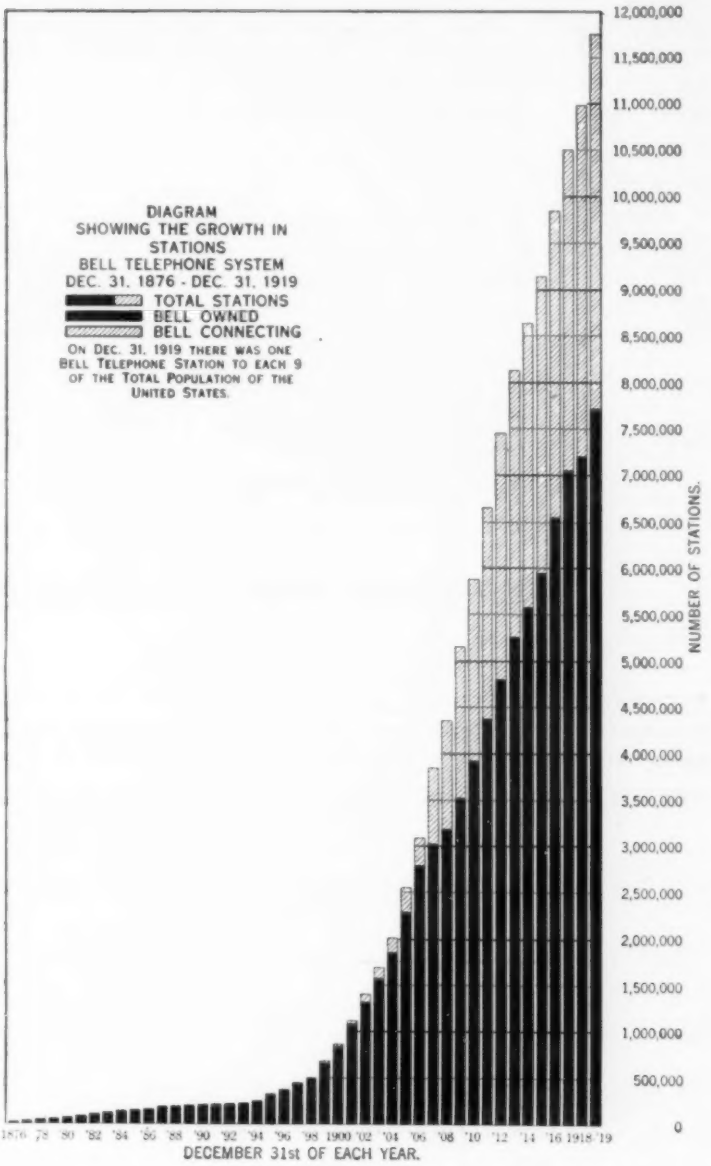


Figure 3

Telephone development statistics, such as were shown in the preceding charts, are valuable over-all indicators of how good a job we have been doing in providing telephone service. If we were not doing a good job, no such growth would have been demanded by our customers. But to make sure that we maintain the high standards of service desired and that the service is still further improved,

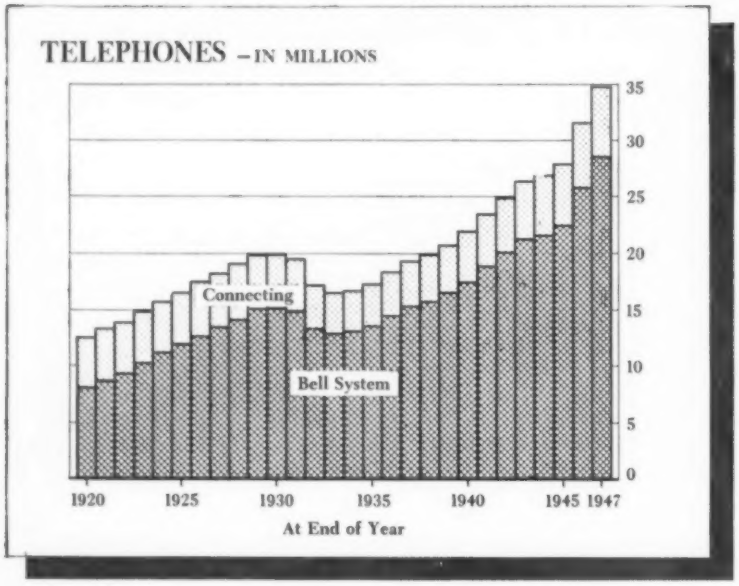


Figure 4

a constant check must be kept on numerous components of performance. Chart 5 illustrates one such measure of performance. This chart shows that, for manual telephones, only about four percent of all calls take more than 10 seconds before the operator answers. This current per-

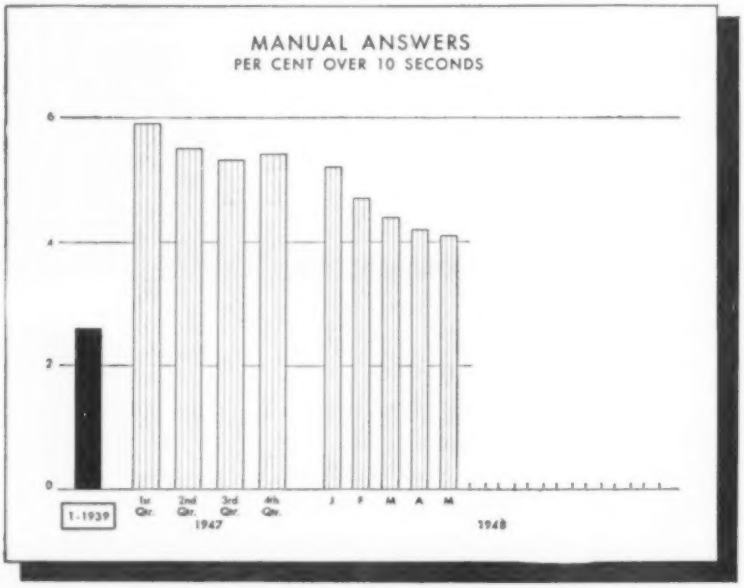


Figure 5

formance shows a definite improvement over the preceding months this year, and is very much better than the general level during last year. However, it is still not as good as the best previous performance, achieved in the first quarter of 1939. No other method of presentation would tell this story as quickly or as well as does this simple chart. Together with many other carefully developed results pictures, this chart tells the story of whether or not we are doing a good operating job.

In addition to the many internal checks made on quality of service, our business also makes a continuing check on what our customers think about the service. Figure 6 is typical of the charts used to picture the results of the System-wide Customer Opinion Surveys that are made at frequent intervals.* This chart shows very clearly that most of the people who use telephone service think it is "excellent" or "good," and that the percentage who think so is slightly higher now than during any preceding survey in this series. Public opinion information such as this serves as a supplement to internal service measurement. It helps to explain when and how our customers agree or disagree with our own estimates of the kind of job we are doing,

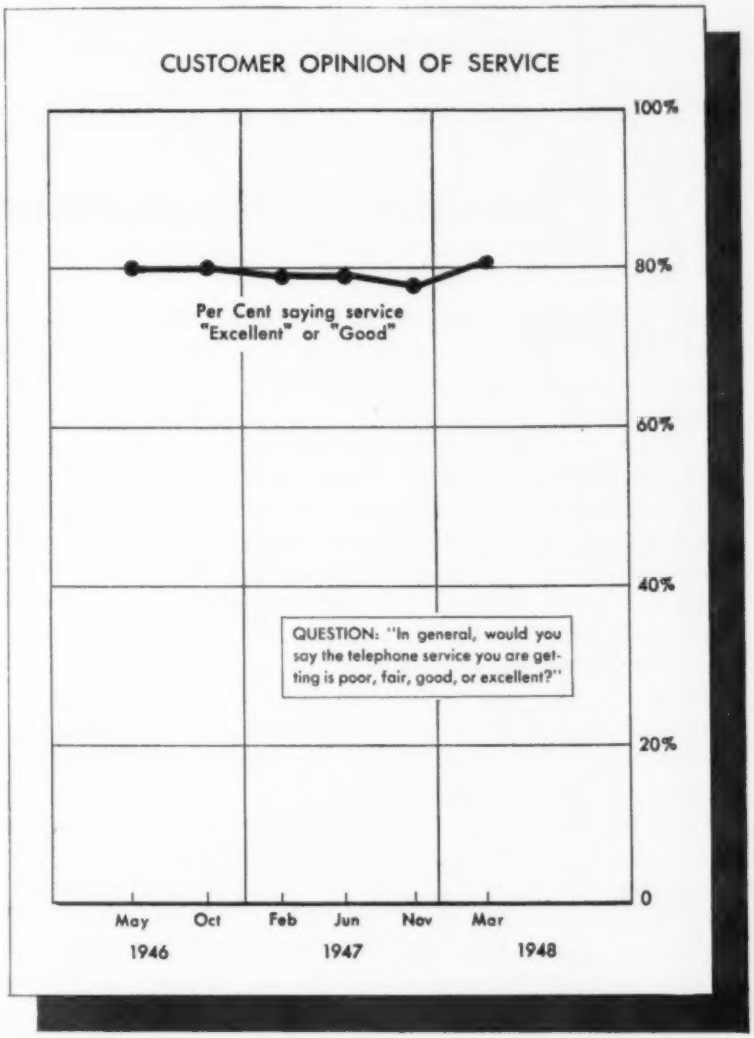


Figure 6

* See "Finding Out What People Think of Us." MAGAZINE, Spring 1946.

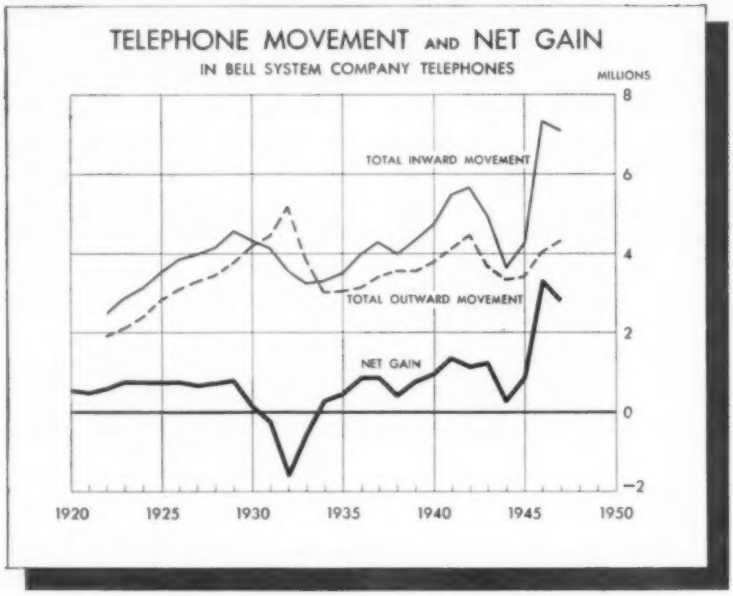


Figure 7

and to point out the particular parts of the job with which they may be dissatisfied, or about which they may have an unfavorable attitude.

Figure 7 is an example of a slightly less simple chart variety. Going back to the subject of telephones again, this picture shows not only how much station activity we handled but also the net results of this activity. All such net results, which are the difference between an adding and taking away, can be presented in this sort of cause-and-effect picture. It has the advantage of telling both how we stand and how we got that way. For many internal management uses, this type of chart is of unique value. The inclusion of the background data from which the net result was derived gives it an entirely different slant from any of the preceding charts. One of the fascinating facts about charts is that they are almost infinitely variable. Although there are only a few basic types of chart, each can be modified and adjusted to serve the specific requirements of the job it has to do.

Figure 8 is a sample of the standard method of linking together a series of cross-section pictures such as the pie chart shown in Figure 1. This type of chart is not only a great deal more compact than a series of pie charts would be, but it is much more useful for bringing out shifts in the importance of each component over a period of time. This picture differs from the type of picture shown in Charts 3 and 4 in that it shows relative amounts: the size of each component is not measured in absolute terms such as dollars or telephones, but only in relation to the size of other components. This example shows that in 1920 Land and Buildings and Central Office Equipment combined accounted for about 29 percent of the total Plant Invest-

ment, whereas currently they represent about 43 percent of the Total Investment.

At first glance, the chart in Figure 9 may seem a trifle forbidding; but it is really simpler than it seems. This ingenious chart does the work of two charts. It shows first, by the heavy unbroken curve, how many telephones were gained each year, and up to this point it is a simple trend chart similar to some of the examples already shown. What makes this a chart of distinction is the band of light broken curves set behind the net-gain trend line. This device makes it possible to see at a glance not only the number of telephones gained each year—as shown by the scales in the right margin—but also how big each gain was in relation to the number of stations already in service. In other words, this chart shows first how big a job was done in terms of work performed and, second, how important it was in terms of expanding the service.

Similar charts are used to picture other aspects of the business; for example, to show income in relation to plant investment, and other ratios indicating the financial health of the business. By such charts as this, the managers of our business can see not only what the results are but also can view them in their proper perspective.

Moving a step further into the field of statistical presentation, the chart in Figure 10 illustrates a form of analysis that has many useful applications in our business. It is generally known as a semi-logarithmic chart because one of the scales is logarithmic instead of arithmetic. This type of chart is easily recognized by the uneven spacing of the scale rulings.

The major purpose of this chart is quite different from that of any

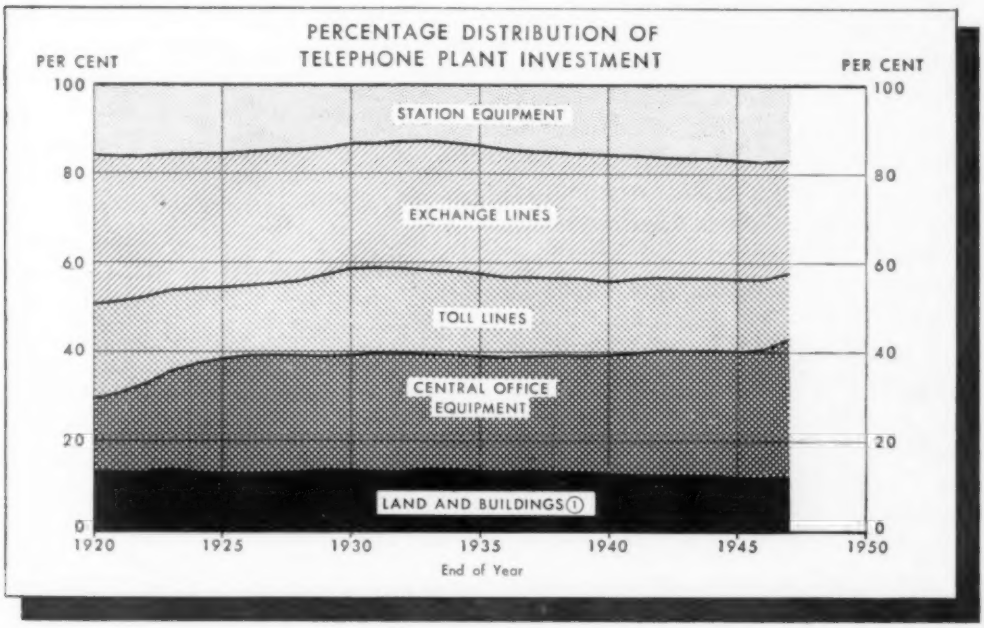


Figure 8

other of the preceding types. In one way or another, all of the other examples pictured magnitude, that is, how big something was compared to something else, or compared to some other time. This chart, although magnitude can be *read* from the scale, makes no such comparison because it does not *picture* size. Instead, it *pictures* speed of growth. In the other examples, the basis of measurement was the *distance* between curve and base line, or between one curve and another. In this chart, the basis of measurement is the *slope* at which the curve moves. It does not show, as it might seem to a reader unfamiliar with this type of chart, that extension telephones now represent nearly one half of the total number of telephones. It does show, however, that recently they have been increasing at a faster rate than the total.

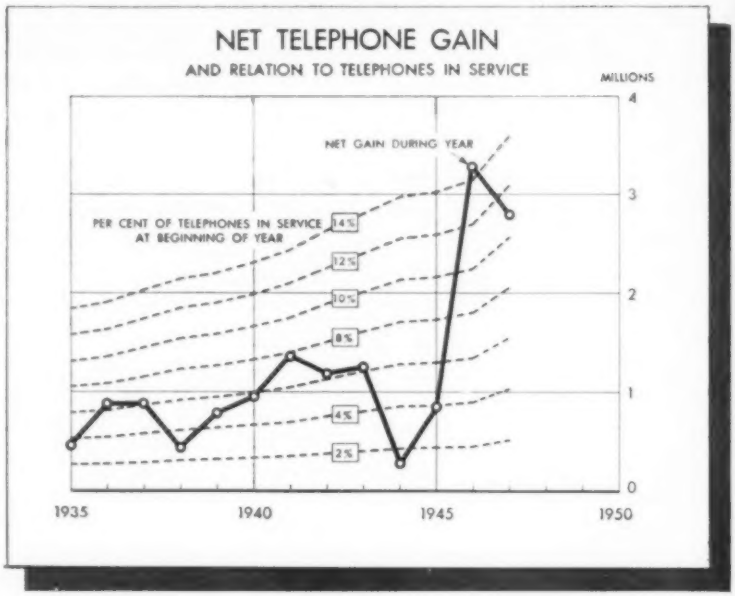


Figure 9

The special feature of this type of presentation is that a given percentage growth always takes the same angle, no matter where it occurs on the chart. This is not true of arithmetic scale charts, of which Figures 3–9 are typical examples. This type of chart tells a story that no other chart can tell. It provides still another means by which management can evaluate results and can gauge their significance.

MANY OTHER KINDS of charts, on many other subjects, and made for many other uses, could be placed in evidence to demonstrate how charts do their part in helping to provide good telephone service. The ten examples selected here are a representative few chosen merely for purposes of illustration. Most of them appear in recurring reports or analyses, and all of them are actively used to provide a particular kind of information to a specific audience. Although most are extremely simple, and only hint at the analytical uses to which charts may be put, all of these examples tell a pertinent story about some measurable fact of the business.

To the people who make charts, and to many more whose knowledge of the business and judgment of its condition are aided by charts, all of

this may be "old stuff." It is set down here to indicate to others, whose contact with graphic presentation may be limited, that the making of charts—like many another activity in the business—is a specialized art, representing a considerable degree of training and skill.

In almost every corner of the business, at all levels of its management, ways have been found to measure the task, to measure the results, and to use these measurements as guides toward doing the job even better. For those many measurable facts of the business, whether they relate to operating results, to accounting, to financing, to public relations, or to purchasing, planning, or research, charts provide an invaluable means of expression.

It is true that some subjects are not suitable for chart presentation, and that a great many chartable facts can be shown just as well or better by other methods of presentation. But when a picture is wanted instead of precise figures, and when the nature and importance of the information warrants the preparation of a picture, charts are the answer. These ingenious devices for putting figures into graphic form are important tools of management, and in the telephone business these tools are widely and intensively put to work.

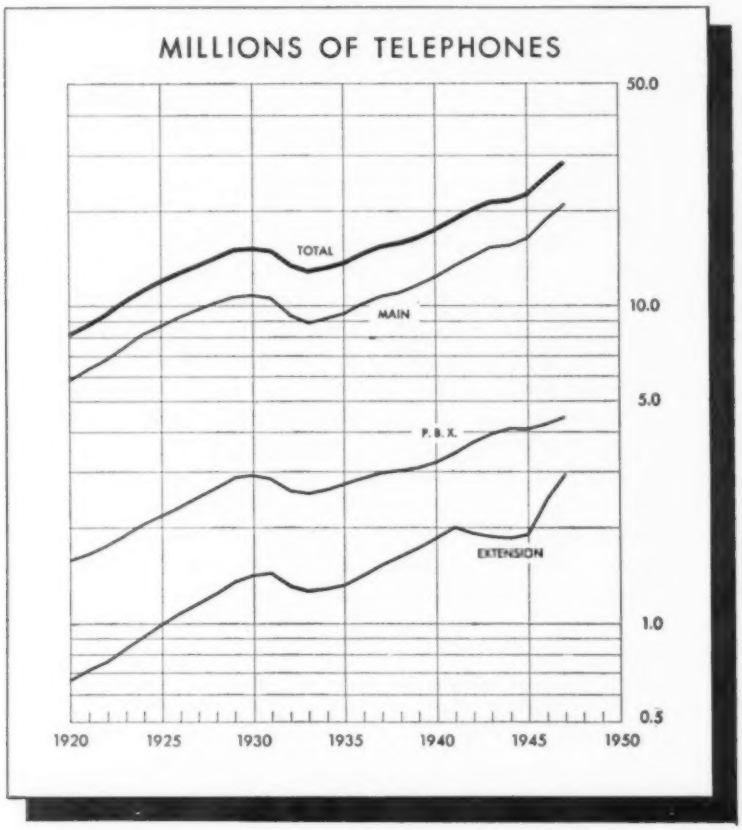


Figure 10

Twenty-five Years Ago in the

BELL TELEPHONE QUARTERLY

Items from Volume II, Number 3, July 1923

The New Bell Flag

THE PRESIDENTS of the Associated Companies of the Bell System met with the executives of the American Telephone and Telegraph Company for a five-day conference at Yama Farms, on May 26th. . . . A feature of the conference was the adoption of a Bell System flag . . . to be flown from hundreds of Bell-owned buildings, to suggest the national character of the service as well as the immense physical resources of the Bell System.

A Privacy Radio System for Catalina Island

THE RADIO TELEPHONE SYSTEM linking Catalina Island, thirty miles off the California coast, with Los Angeles, has been equipped with a new development of Bell System engineers which may be called a privacy system for the radio telephone. The new system was placed in service on June 9, and the preliminary tests and actual use in service show that speech is as good in quality and volume as before its introduction, and is not intelligible to those attempting to listen to it with ordinary radio receiving apparatus.

Not only does the wireless link connect the island with Los Angeles but, through the trunk lines of the Bell System, it puts the residents of the island in telephonic touch with every commercial center of the United States. It was part of the longest telephone circuit on record when, in the opening of the Havana-Key West submarine telephone cable, a circuit of over 5,000 miles was established, by radio, by land wires, and by cable, between Catalina Island and Cuba.

The A. T. & T. Company Opens New Broadcasting Studios in New York

THE NEW broadcasting studios for use in connection with Station WEAF of the American Telephone and Telegraph Company were formally opened on the evening of April 30. These studios are located at 195 Broadway, New York City, and embody important modifications adopted in an endeavor to improve the quality of broadcasting.

In July, 1922, the company began broadcasting through Station WEAF with a single studio located in the Walker-Lispenard Building at 24 Walker Street. Although this studio was designed in accordance with the best practice known to the radio art at that time, the experience of six months indicated desirable modifications in studio design. It was also found that the location at Walker Street was not sufficiently accessible for the many artists who take part in the broadcasting programs; consequently, the new studios are located in the Telephone and Telegraph Building at 195 Broadway. Special telephone circuits connect the studios with the radio transmitting equipment at Walker Street.

The two outstanding improvements in the new studios are: (1) means to eliminate waits in programs by the use of two studios, and (2) a more effective monitoring equipment by the installation of a novel announcer's booth.

A large studio is provided for bands, orchestras, and glee clubs. A small studio is used for soloists and speakers. While an orchestra is being assembled about the microphone in the large studio, a singer or

speaker is broadcasting from the small studio. When the singer has completed a number and the orchestra is ready, the large studio is switched on without any delay; hence, it is possible to alternate from one studio to the other without lapses in the program. Artists may rest between numbers, because the necessity of singing six or seven numbers successively is eliminated.

On the opening evening, a special program covering a wide range of entertainment was broadcast for the benefit of the newspaper men, music and dramatic critics, and the radio editors who attended. Mr. Edgar S. Bloom, Vice President of the American Telephone and Telegraph Company, opened the new studio and in the course of his remarks gave a brief history of the Company's broadcasting activities.

"The American Telephone and Telegraph Company began broadcasting on July 25, 1922, on 360 meter wave length, being on the air twelve hours weekly. On October 2, 1922, we changed to 400 meter wave length, which has been used since that time and we are now broadcasting about thirty hours weekly.

"During the nine months that we have broadcast, nearly 200 of America's leading statesmen and citizens have spoken to you through WEAF, also many stars of the first magnitude in the theatrical and motion picture world. Over 200 separate programs have been broadcast involving a total of 3,000 people including artists. According to our best estimate, there are probably upwards of three-quarters of a million radio receiving sets within the area easily reached by our station, and, as these sets will probably average not less than three listeners per set, we have a possible audience of between two and three million people."

The Bell Public Address System

FROM THE TIME of Stentor down to a period within the last one or two years no human being has ever possessed a voice equal to this character of mythology. It remained for the Bell engineers to turn mythology into fact, and today through the Bell Public Address System any man can have the power not only of fifty voices but of fifty thousand times fifty voices.

For outdoor occasions, the projectors are connected to square wooden horns about fifteen feet long and having a cross-section which varies from an inch at the receiver end to several feet at the mouth of the horn. A battery of eight or ten of these horns spaced uniformly around a circle, when supplied with the highest power from the amplifier, will enable a speaker's voice to be heard by at least five hundred thousand people gathered within a diameter of half a mile.

Some time ago one of these high-power "loud speakers," as they are sometimes called, was installed experimentally in the Catskill Mountains, and under favorable conditions it was possible to hear the speaker's voice for three and one-half miles through one of the mountain valleys. Not since the days of Rip Van Winkle, when the mystic crew of Hendrik Hudson were reputed to play at ten-pins with thunder clouds, have these peaceful valleys reverberated to such a mighty volume of sound.

The Bell Public Address System has been successfully used at many great gatherings, such as the inauguration of President Harding, the Arlington ceremonies at the burial of the Unknown American, the dedication of the Lincoln Memorial, and other similar occasions.

Things May Be Temporal, but Ideas Are Eternal: The Great Truths of Science Live and Are Preserved in the Minds and Experience of Mankind

Ideas, Men, and Things

James O. Perrine

The following paragraphs constitute the major part of an address delivered at the seventh annual "Science for Everyone" Congress sponsored by Hartwick College, Oneonta, N. Y., on May 1, 1948.—EDITOR.

THE SUCCESS of science involves a number of observations and concepts of a great many people: it is achieved by coöperative human effort. It is a story of the skills and talents of men. Developments and achievements build upon ideas and concepts dating back through many years. There is no black magic along the path of science, no talisman secretly possessed by scientists which vouchsafes success. The scientist has no inner light, no esoteric intutition. Sir Humphrey Davy, one of the greatest of scientists, who lived 125 years ago, said: "Practically all of the contributions it has been my good fortune to make were suggested to me by failures."

In these days of great laboratories, both industrial and university, involving elaborate and costly apparatus and thousands of trained experts, it is well to reflect that most of the great heritage of science that is now ours was achieved with crude, rudimentary, and homespun equipment. Volta, Davy, Faraday, Henry, Morse, Bell, Franklin, and Edison made great creative discoveries with simple equipment. Galileo and Newton were able to conduct experiments with very little apparatus, in ordinary buildings. Even in the nineteenth century Lord Rayleigh was famous for the skill with which he made observations of the greatest precision with apparatus which he constructed from pieces of wire, wood, and sealing wax.

Sir Francis Bacon, born in 1561, emphasized observation and experiment, rather than blind acceptance of tradition.

Aristotle's naïve assumption that bodies should fall with velocities proportional to their weights was doubted by Galileo. From the top of the

Leaning Tower of Pisa, Galileo showed by direct experiment that Aristotle was wrong. For such doubt —and other doubts about the world, the stars, the sun and planets— Galileo was arrested, threatened with death, imprisoned for a while and forced to spend the rest of his life in seclusion.

The effect of Galileo's experiments and astronomical observations with a telescope was much greater than the mere demonstration of a new fact might be assumed to be, because it tended to destroy the authority of Aristotle and to teach men that the validity of a fact is to be tested by direct experiment instead of by quotation of any authority, however great.

Amateurs and Accidents

GREAT TRUTHS, great discoveries, great advances are not always made by experts. In many instances, important discoveries in many branches of science were made and are now being made by amateurs. Great advances in science have arisen from a study of simple phenomena. Newton said, "Nature is pleased with simplicity."

Brashear, the great lens designer and polisher, was a Pittsburgh coal miner, an amateur. He became a distinguished scientist. Professional astronomers oftentimes came to him for expert advice.

Priestley was a devout minister, not a trained chemist; yet he discovered oxygen.

Michael Faraday, often called the greatest experimenter of all time, and one of the illustrous names in electrical science, had no formal training, no academic degrees. As a boy of humble heritage he was a janitor and bottle washer in the laboratory of Sir Humphrey Davy. Davy once was asked what was his greatest discovery. Davy promptly answered: Michael Faraday.

Furthermore, it is literally true that many great discoveries were accidental. That is the way it has to be. We must not attach any stigma, any criticism, to the word "accident." No one knows what is ahead in the realm of basic truth and phenomena; no one has any inside track to truth.

Of course, to have an accident happen—to discover something accidentally in chemistry, biology, physics, electronics, medicine, etc.—one must not be looking *at* something but must be looking *for* something: must be alert, must have an open mind, must be working, experimenting, testing, in a laboratory or field; must have a sharp wit to see the answer nature is ready to reveal. Like Mr. Micawber in David Copperfield, one must expect something to turn up.

To discover accidentally is not reprehensible, is not an indication of laziness of body or mind, is not a bit of good luck. A miner, a prospector does not strike a bonanza while playing gin rummy. He goes to the hills and looks for gold, silver, coal, gas, and oil. A scientist does not accidentally—in the generally accepted sense of that term—make a great discovery while playing golf. After all, Isaac Walton made no significant scientific discovery while angling.

Oftentimes the very new appears absurd or contrary to common sense. We must not be too quick to scoff at the seeming absurdity of a new idea, lest we miss the possible validity of that new idea. Both the quantum theory of Planck and the relativity

theory of Einstein seemed to be completely absurd when introduced. Fowler wrote, in 1934: "Nothing could have exceeded the apparently wild extravagance of de Broglie's first work on electron waves which led directly to quantum mechanics."

What appears to be classical through the years may be nonsensical tomorrow. What appears to be iconoclastic today may be eternal truth tomorrow.

Mother Nature is not a garrulous, kindly lady in lavender and old lace. She is a sphinx; she zealously guards her broad, basic truths, her elemental phenomena. She locks them in strong boxes. The jewels in her treasure chest are not presented on a silver platter. To find the keys, to unlock the chest, the scientist must have curiosity, determination, imagination, and intelligence.

One example is often worth a dozen arguments. I shall therefore no longer recite generalities, but shall offer some concrete examples which are pertinent to the thesis, "Ideas, Men, and Things."

Gregor Mendel and His Garden Peas

The story of the great research of an almost unknown Austrian biologist, a monk, Gregor Mendel by name, is a thrilling one.

Mendel worked with edible peas which he grew in the garden of his monastery. He cross-bred the peas differing in one or a few sharply contrasting characters. These differences he followed through generations, always counting accurately the number of plants showing each character. He published his findings in an obscure journal in 1866. His paper reported important facts regarding the character of offspring as related to the character of the parents.

His article, "Distributive Mechanism of Organic Inheritance," was sent to London and elsewhere, but scarcely any one paid any attention. A great truth, a great principle, lay on the dusty shelves of the libraries of Europe for a long time. A generation later, in 1900, his paper was discovered independently by three scientists in different parts of Europe. One of these was DeVries of Holland. It was at once realized that a very important discovery had been made, so important indeed that the study of heredity is to this day often called Mendelism. The laws of inheritance were found to be not peculiar to the edible pea but of universal application to plants and animals, including man.

No one would have guessed that Mendel's study of peas in 1865 would be of utmost importance in the breeding of cattle in 1948.

It takes so long for ideas to grow up.

Josiah Willard Gibbs and the Phase Rule

In the roster of really great American scientists there is a man whose name and work are little known by the general public, even though chemical and chemical engineering careers are today the ambition of many youths.

Josiah Willard Gibbs was a shy, retiring, studious lad at Yale about 1858. He loved the classics in Latin and Greek. After a while his interest turned to chemistry, particularly to physical chemistry. He did not like test tubes, crucibles and malodorous gases too well. Theoretical considerations challenged his talent more than things in a laboratory.

In 1876 he published a paper in an obscure journal of the Connecticut Academy of Science. This paper was entitled "On the Equilibrium of Heterogeneous Substances." Few physical scientists knew of the paper, and those who did know of it did not recognize its real worth. A quarter of a century passed. Then a German chemist, Ostwald, in 1891 translated the paper into German; and later, in 1900, Roozeboom did experimental work carried out on the basis of Gibbs' principles. The

principle called the Phase Rule is now recognized as of the highest value in the great chemical industries of the world today.

Salt, water and coal—three components in a chemical plant—may be in different phases such as gaseous, liquid, and solid under different degrees of freedom such as temperature, pressure, and concentration. How various components, different phases, and varying degrees of freedom must be interrelated and controlled to produce an alloy, a plastic, or a synthetic textile, is specified by Gibbs' Phase Rule.

The really important aspect of Gibbs' Phase Rule is not the things involved, but the principles: the concept, the understanding.

An idea tried so hard to be born in 1876. A quarter of a century elapsed before Gibbs' Phase Rule received the recognition it so richly deserved.

Roentgen and X-Rays

1946 was the 50th anniversary of the discovery of X-rays in 1896. That discovery marked the brilliant dawn of the present electronic era.

Prior to Roentgen's notable discovery, Morgan, Faraday, Hittorf, Geissler, Crookes, and Lenard had been studying conduction of electricity through gases at low pressures in glass tubes. As early as 1785, William Morgan, in a paper before the Royal Society, referred to the glow that could be obtained when electricity was passed through an evacuated vessel.

The first systematic and thorough research on electrical conductivity through gases was that of Faraday, in 1836. In 1869, Hittorf published further investigations on electrical conductivity in gases. Crookes did a great deal of research, and called the cathode rays in his tubes, now accepted as electrons, the fourth state of matter.

In 1896, Roentgen covered the Hittorf-Crookes tube with a piece of black paper in a study of the cathode rays—electrons, as we call them today. When this was done, something extraordinary happened. Some fluorescent crystals glowed brilliantly. The room was dark, paper covered the Crookes' tube; yet some kind of light, a new kind of light as it were, caused the fluorescent crystals to glow. Then Roentgen noticed that the new kind of light penetrated the paper and pasteboard cover about some photographic plates and blackened them. The new kind of light had gone through opaque material.

There was no theory that predicated the existence of the X-rays. They were the result of man's study of electrical phenomena dating back many years. Perhaps Morgan, previously mentioned, produced X-rays one hundred years before but had not realized it. Hittorf and Crookes certainly produced X-rays hundreds of times. Crookes actually fogged a box of photographic plates in his laboratory about 1886. At that time he wrote to the London firm who had sold him the plates and complained that the plates were defective. When he heard of Roentgen's discovery, he realized that the allegedly defective plates had been blackened by X-rays from his own vacuum tubes. He did not have the apperceptive wit to observe the answer nature had laid before him.

Roentgen had made a startling, a brand new, a really momentous discovery. When asked by friends: "What were your impressions; what were your inward reactions when you realized you had found a new kind of radiation; what did you think?" Roentgen cogently replied, "I didn't think, I investigated."

The nature of the new radiation was not known, and could not be fitted into the pattern of contemporaneous knowledge. Hence they were called X-rays. For many years nature kept her secret, even though skillful investigators kept pelting her with questions. X-rays could not be bent, like light waves, through a lens. They seemed to defy any attempts to be diffracted.

Then in 1912—two score years later—Max von Laue used the closely packed and regularly arranged atoms of a quartz crys-

tal as a diffraction grating. Then X-rays became a member of the electromagnetic family. They were very short waves. Their longer brothers were ultra-violet light, visible light, heat waves and radio waves. Their wavelength was one five-thousandth that of light.

For a hundred years men were on the brink of discovery of X-rays. Ideas try so very hard to be born; it seems that basic discoveries need to be nurtured for many years in the cradle of time.

Radio Waves and the Electromagnetic Spectrum

Newton, perhaps the greatest scientist of all time, did a most beautiful experiment when he sent a beam of light through a prism. The white light was split into seven lovely colors: red, orange, yellow, green, blue, indigo, violet. The beauty of the rainbow, the raindrops separating the sunlight into brilliant colors, took on an even greater beauty: that of understanding. Visible colors, ultra-violet light revealed by fluorescent minerals, and heat waves—all appeared to be members of one family.

But what was the physical, the innate nature of these waves? What was the quality of this family?

The answer was supplied by J. Clerk Maxwell in 1865. He studied mathematically the propagation of electric and magnetic forces in space, and found the velocity of propagation to be identical with the known velocity of light. He set forth the brand new idea that light waves were really electromagnetic waves; radio waves, as we say today. Thus he considered visible light as a restricted portion of a broad array of radiation of different wave lengths and frequency. He predicted that longer waves might exist which would be far too long to be seen by the eye but which could conceivably be produced and detected by other means, perhaps by distinctively electrical techniques.

Here was a great question put to nature, put to man to investigate.

Again, as in other fields of research, almost a quarter of a century elapsed before the right key was found to unlock a particular drawer in nature's treasure chest, which contained the jewel Maxwell thought was there. In 1887, Heinrich Hertz confirmed experimentally Maxwell's theory. Radio waves are sometimes appropriately called Hertzian waves. The radio waves produced and detected by Hertz were what we today call short waves. His radio waves were ten feet long, 100 million cycles per second in frequency. Also he experimented with shorter waves: about two feet long, 500 million cycles per second in frequency.

Fifteen years after Hertz, very long waves were used by Marconi. Medium-long waves were used for broadcasting thirty years after Hertz.

1887 to 1937 is fifty years. And this half century had to be eked out before the short waves of Hertz were put to use by man for communication.

The electro-magnetic family is a great family of vibrations; there are about eighty octaves of them. The entire gamut of these eighty octaves has been experimentally investigated. Long heat waves have met short radio waves. Ultra-violet waves have met X-rays and X-rays have met the gamma waves emitted by radium. In the realm of electric power and communications electric waves, thirty octaves of them, ranging from 25 cycles per second to 30,000 million cycles per second, are playing a role in the business and social affairs of man.

Maxwell and Hertz, with their great analytical talent and experimental skill, had fashioned a great amphitheatre of understanding out of which opened many doors.

It took a long time for the first short radio waves ever produced to get into the affairs of men and carry speech, music, and television over land and sea.

Electronics

More than a hundred and fifty years ago, Dufay, in France, observed that an object

charged with electricity—a piece of sulphur that had been rubbed with a woolen cloth, a glass rod rubbed with silk—lost that charge more rapidly when hot than when cold. Why this was true, no one hazarded a guess.

When Edison was developing the incandescent electric light in 1880, he was bedeviled with a strange phenomenon. That the hot filament of his light was actually boiling out billions of charges of electricity was not ever dreamed of by Edison, perhaps the greatest inventor of all times. He was pestered by an unknown phenomenon. He thought so little of the annoying and seemingly useless effect he encountered that he, a great inventor seeking to patent everything he could, not only made known his observations to a visitor from England, Sir William Preece, but also made some extra lamp bulbs and gave them to Preece to take home and study at his leisure.

It took two-score years for John Ambrose Fleming to develop a useful electrical device, the Fleming valve, taking advantage of the effect which had pestered Edison. In the years to come, the Edison effect, so called—the emission of electrons by a hot object—which Edison did not think enough of to investigate further, will be considered one of his greatest discoveries.

Prior to Edison's observation and Fleming's making of an electronic rectifier, charges of electricity had been pulled out of a cold cathode by sheer brute force of a high voltage. But Fleming, J. J. Thomson, and O. W. Richardson, at Princeton about 1915, rationalized Edison's observation. It was discovered that incandescently hot objects did in generous fashion what Dufay observed over a hundred years before: electrons, negative charges of electricity, seemed to take their departure spontaneously from the hot filament.

Before these observations and the rationalization of them, no one had the imagination to predict that charges of electricity could exist as such, separate from an atom of matter. The first device utilizing this brand new concept was the Fleming valve, or rectifier. By it alternating current could be converted to direct current. It gave promise of being, like a piece of natural crystal, a detector of radio waves. Today, great electronic rectifiers are used in telephony and broadcasting and television to change high-voltage electronic alternating currents to high-voltage direct currents.

After Fleming and his two-electrode valve, a diode, DeForest made his brilliant invention of the three-electrode valve.

Following DeForest came the brilliant researches of H. D. Arnold of the Bell Telephone Laboratories and Irving Langmuir of the General Electric Company. Greatly improved vacuum pumps made it possible for Arnold and Langmuir to investigate, thoroughly understand, and control the performance of electrons, unhampered by association with molecules of gas, in a very highly evacuated glass bulb. Nowadays we have four-electrode valves, tetrodes; and five-electrode valves, pentodes. We have greatly improved X-ray tubes, cathode ray tubes, television tubes, and millions of vacuum tubes in wire and radio communications—all electronic tubes.

So years after the first observations in 1880, an annoying phenomenon, not understood, turns out to be one of the really great observations of all time in the field of electricity.

There is no source of electricity in nature except the intractable lightning flash and the phenomenon of static electricity, which even today have very little application to the needs and wants of man.

But electrons—infinitesimally small, negative charges of electricity—are made to do our bidding in glass bulbs. Sometimes the bulbs are almost perfectly evacuated; sometimes the bulbs are filled with gases—neon, nitrogen, mercury vapor.

No idea, no field of understanding, no principles, no know-how has spent a greater period in the cradle of time than has the science of electronics. No field of physics,

of electrical engineering, has borne greater fruits, made possible more and finer application to the affairs of man than the opening of nature's treasure chest which contained the jewel of electronics. Many attempts were made over a long period of years by many men in many different countries to find the keys. Conspicuous success has been achieved.

It seems that basic phenomena, ideas, and techniques have to be nestled for so many years before they even try their wings.

Piezo-Electricity

Electricity—positive and negative charges—is present in all things at all times; it is here, there, and everywhere. Every substance and every object in the universe consists of a vast and turbulent array of electrical charges.

Electricity is not, in its own right, a useful commodity in everyday life. It is not like air, water, metals, food, flowers. Rather, it is the amazing quality of electricity to enter into entangling alliances with various forms of power and energy that entitles it to be regarded as one of the greatest servants of man. Electricity is not power, not energy. Electricity has but one role to play in the affairs of man: to act as the number one intermediary in the various interrelations of power involved in heat, sound, light, chemical and mechanical power.

In giant electric generators, mechanical power derived from heat and water power twists an armature round and round. Power in an electro-magnetic form, really in the form of electro-magnetic waves, is thus available to be guided by wires to factory and home, to be translated back into heat and work, and of course to produce light too.

However, there is one most interesting and striking method whereby mechanical power can be changed directly to electrical power. No intermediate apparatus, like the generators of a power station or the dynamic microphone of communication, is necessary.

This direct manner of changing mechanical power to electrical power is possible because of the innate quality of many types of natural crystal, like this quartz crystal I have in my hand. If I give this crystal a mechanical blow, a pull, a squeeze, a twist, one face will be charged positively, another face negatively. The Greeks had a name for it, "piezo" or pressure electricity.*

Crystals were observed to have electrical properties centuries ago. A history of electricity was written in 1767 by Joseph Priestley, discoverer of oxygen. In this history, Priestley talks about the electricity of the tourmaline. Tourmaline is a natural crystal.

In 1828 André Becquerel described experiments in which mechanical stress was applied to quartz and other crystals to produce an electric charge.

Pierre Curie and his brother Paul studied piezo-electricity and published their findings in 1880. It was they who first thoroughly investigated and rationalized the pressure-electric effect.

Another jewel, literally as well as fig-

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* At this point an experimental demonstration of converting mechanical energy to electrical energy and vice versa was presented.

A rochelle salt crystal was given a heavy blow with a mallet. A two-foot neon tube in spiral form was momentarily lighted by the electrical charge from the crystal.

The same crystal was then connected to an amplifier and loudspeaker. A vibrating tuning fork was placed on the crystal mounting, with the result that its tone could readily be heard by the listeners. The tick of a watch was made audible to the audience.

The crystal was finally placed against the throat near the vocal chords. The vibrating vocal chords activated the crystal so that it could serve as a microphone. Intelligible speech was thus emitted from the public address system.

To illustrate the direct conversion of electrical energy to mechanical, a vacuum tube oscillator with its alternating charge was connected to a quartz crystal wafer. Audible sound due to the vibrating crystal was emitted. By touching the crystal with a bit of cotton on a small stick of wood, the sound stopped. The vibrating crystal was thus illustrated to be the source of mechanical vibrations, of sound. A tone of 2000 cycles per second and another of 4000 cycles per second were used.

uratively, was now found in nature's treasure chest.

Generally speaking, the piezo-electric effect remained a curiosity—a useless, interesting phenomenon of the physicist's laboratory—for thirty-five years.

Then, during the war of 1914–1918, Langevin of France made some brilliant attempts to use quartz crystals as a source of sound in submarine detection by the echo method under water.

In the 1920s, Professor Pierce of Harvard and Professor Cady of Wesleyan University made conspicuous contributions.

In recent years, a number of researches in the Bell Telephone Laboratories have resulted in a most comprehensive understanding of the properties and of the cutting of crystals for communication purposes. Synthetic piezo-electric crystals are now made which, in some respects, have characteristics comparable to natural quartz crystals.

Synthetic crystals are grown from seeds placed in a chemical solution. It takes a few weeks or so for a crystal such as this one in my hand to grow. It perhaps took centuries for the seeds of quartz crystals to grow in nature's own laboratory. Seeds of observation and understanding were found in connection with piezo-electric crystals over one hundred years ago. It took a very long time for these seeds to grow. Who would ever have dreamed, one hundred years ago, that a shimmering sheet of rock would play a part in an electrical system to keep almost perfect account of seconds? Who, one hundred years ago, would have had the temerity to predict that mechanically vibrating plates of rock would play an electrical role in the drama of sending articulate speech and beautiful music to millions of homes by radio broadcasting stations and in helping to guide and distribute hundreds of telephone messages to the proper person or business office after they had traveled simultaneously over a single pair of wires from a distant city?

Epilogue

THE PATH to ideas, to understanding, is not easy, is not rapid, is not a royal road. In what I have told about a number of great scientists and the ideas they evolved, and the things they helped produce in usable form, you will readily subscribe to the thought already stated several times: "Ideas try very hard to be born." It takes a long time for a youth to grow up. It also takes a long time for ideas to grow up. It seems that so many ideas have to be nurtured so very long in the cradle of time. Sometimes ideas do not seem ever to grow up.

You will agree with Browning who wrote: "Ah, but a man's reach should exceed his grasp or what's a Heaven for?"

The really basic problem is one of ideas, concepts, principles; of know-how, of intangibles, imponderables. The quintessence of the problem is *spiritual.*

Mind you, I do not say *theological.* I mean the deep and broad ethical and spiritual values; I mean the eternal verities.

To solve this problem effectively means education, the promotion of concepts of tolerance and forbearance, of world-wide understanding—a philosophy, if you will. We must be right in our minds, in our attitudes, to prevent all the physical things we have made from becoming Frankenstein monsters which destroy. They can be blessings, which make for happiness. What they are and what they become depends on our spirit.

Things may be destroyed; structures may be broken down by storms and earthquakes; trains may be

wrecked; airplanes may crash in fog; bridges may be torn from their footings by a rushing torrent of water and ice. Telephone cables and radio antennas may be broken down by ice; a telephone central office connecting thousands of subscribers may be ruined by a fire.

These are all great disasters. But, after all, only things are involved. The knowledge, the know-how, the principles of mechanics, the great truths of design and manufacture, the basic understanding of chemistry, of electrical principles and of electronics, are still in the minds and experience of men, in the treatises and in the books written and published by men. These latter cannot be lost, cannot be destroyed. They are permanent, durable, everlasting; even more everlasting than the hills.

The advances of electrical communication by wire and radio will not of themselves make for better understanding among the races of the world. If people are tolerant, considerate, are disposed to be friendly, world-wide communications may help. But if races are disposed to be mad, inconsiderate, obstinate, unwilling to try to understand others, rapid communication may excite more hatred, stir more stubborn obstinacy, more misunderstanding.

But scientists are basically optimists. They, as well as other fine folks in all walks of life—in business, in education, in the professions and in the church—have faith in man's basic and innate goodness. The communications research and operating workers get a bit of a lift and heart-warming satisfaction in realizing that they have learned how to send, on the fantastically swift wings of electric waves over wires and radio, the words, the languages, the music and the pictures of man to the far curves of the world. They like to believe with Pasteur that, in the long run, through the years, ugliness and ignorance will be wiped out by beauty and understanding.

The Greatest Communication Network in History

The following statement of the special Bell System facilities provided at the Republican and Democratic National Conventions in Philadelphia earlier in the summer was made on the Telephone Hour radio broadcast of June 21.—EDITOR.

TONIGHT the eyes and ears of the nation are turned toward historic Philadelphia, where in its huge Convention Hall an event of importance to all Americans is taking place—the national convention of a major political party.

We'd like to tell you about a few of the things the Bell System has done to provide for the Philadelphia conventions—probably the broadest communications coverage in our history. Millions of Americans will hear the activities on their radios; hundreds of thousands will view them on television sets; practically all of us will read the latest reports in our favorite newspapers.

Miles of wire, temporary switchboards, cable, and other needed equipment have been furnished by the Bell System to meet the nation's requirements for television, radio, telephoto, and press services, in addition to the usual heavy telephone traffic. All told, some 70 special or additional services have been provided.

Months of preparation preceded today's first session in Philadelphia's Convention Hall. Hundreds of telephone people—engineers, installers, linemen, operators—working in close coördination, planned, installed and are now maintaining and operating this complete system, one of our biggest jobs of its kind in 70 years of telephone service.

For television, the Bell System's radio-relay-coaxial-cable network linking seven East Coast cities, from Boston to Richmond, has been augmented by additional channels in the coaxial cables.

Reporters and commentators covering the conventions are using private lines connecting Convention Hall with individual newspapers and the press associations.

News photo services, with darkrooms in Convention Hall, are sending pictures over telephoto machines linked by special circuits with the picture service networks.

For radio, new circuits connect studios and floor microphones in the Hall with the four major networks and individual radio stations.

Mobile public telephone trailers, additional switchboards, and a large force of operators are already at work handling local and long distance calls.

Helping to bring to the people of the nation fast first-hand accounts of these great events is another example of the many ways in which the Bell System serves the public need and interest.

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